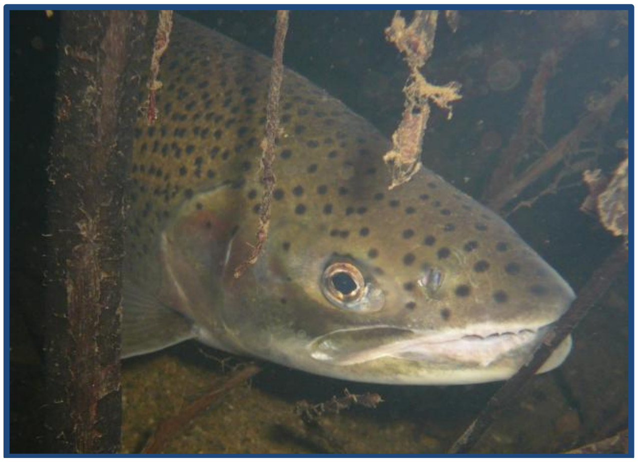
Russian River Biological Opinion
Status and Data Report
Year 2009-10



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Contents

1: Introduction

On September 24, 2008 the National Marine Fisheries Service (NMFS) issued a 15 year Biological Opinion for water Supply, flood control operations, and channel maintenance conducted by the U.S. Army Corps of Engineers (USACE), Sonoma County Water Agency (Water Agency), and Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed (NMFS 2008). The Biological Opinion authorizes incidental take of threatened and endangered Chinook salmon, coho salmon, and steelhead pending implementation of a Reasonable and Prudent Alternative (RPA) to status quo management of reservoir releases, river flow, habitat condition, and facilities in portions of the mainstem Russian River, Dry Creek, and Russian River Estuary. Mandated projects to ameliorate impacts to listed salmonids in the RPA are partitioned among USACE and the Water Agency. Each organization has its own reporting requirements to NMFS. Because coho salmon are also listed as endangered by the California Endangered Species Act (CESA), the Water Agency is party to a Consistency Determination issued by the California Department of Fish and Game (CDFG) in November 2009. The Consistency Determination mandates that the Water Agency implement a subset of Biological Opinion projects that pertain to coho and the Water Agency is required to report progress on these efforts to CDFG.

Project implementation timelines in the Biological Opinion, and Consistency Determination, specify Water Agency reporting requirements to NMFS and CDFG and encourage frequent communication among the agencies. The Water Agency has engaged both NMFS and CDFG in frequent meetings and has presented project status updates on many occasions since early 2009. Although not an explicit requirement of the Biological Opinion or Consistency Determination, the Water Agency has elected to coalesce reporting requirements into one annual volume for presentation to the agencies. The following document represents the first report for year 2009 and will be followed by annual volumes through the year 2023.

Water Agency projects mandated by the Biological Opinion and Consistency Determination fall into six major categories:

- Biological and Habitat Monitoring,
- Habitat Enhancement,
- California Environmental Quality Act (CEQA) Compliance and Permitting,
- Planning and Adaptive Management,
- Water and Fish Facilities Improvements, and
- Public Outreach,

This report contains status updates for planning efforts, environmental compliance, and outreach but the majority of the technical information we present pertains to monitoring and habitat enhancement. The Biological Opinion requires extensive fisheries data collection in the mainstem Russian River, Dry Creek, and Estuary to detect trends and inform habitat enhancement efforts. The report presents each data collection effort independently and the primary intent of this document is to clearly communicate recent results. However, because Chinook, coho, and steelhead have complex life history patterns that integrate all of these environments, we also present a synthesis section to discuss the interrelated nature of the data. Some monitoring programs are extensions of ongoing Water Agency efforts that were initiated a decade or more before receipt of the Biological Opinion. As it is appropriate, we also draw upon results of previous studies to provide context for the information gathered in 2009.

2: Public Outreach

Biological Opinion Requirements

The Biological Opinion includes minimal *explicit* public outreach requirements. The breadth and depth of the RPAs, however, *implies* that implementation of the Biological Opinion will include a robust public outreach program.

RPA 1 (Pursue Changes to D1610 Flows) mandates two outreach activities. First, it requires the Water Agency, with the support of NMFS staff, to conduct outreach "to affected parties in the Russian River watershed" regarding permanently changing Decision 1610. Second, the RPA requires the Water Agency to update NMFS on the progress of temporary urgency changes to flows during Section 7 progress meetings and as public notices and documents are issued.

RPA 2 (Adaptive Management of the Outlet Channel) requires that within six months of the issuance of the Biological Opinion the Water Agency, in consultation with NMFS, "conduct public outreach and education on the need to reduce estuarine impacts by avoiding mechanical breaching to the greatest extent possible."

Finally, RPA 3 (Dry Creek Habitat Enhancements, refers to public outreach in the following mandate, "Working with local landowners, DFG and NMFS, Water Agency will prioritize options for implementation" of habitat enhancement.

The remaining RPAs do not mention public outreach.

Water Agency Public Outreach Activities – 2008

Meetings

Public Policy Facilitating Committee meeting, October 1, 2008 – The PPFC met three days following the issuance of the Biological Opinion. This meeting was the public's first exposure to the document and its requirements. Notices for the meeting were sent out to approximately 800 individuals and agencies; it was advertised in The Press Democrat and community newspapers; and a press release was issued one week prior to the meeting. Approximately 100 people attended the meeting and heard presentations from NMFS and DFG about the need for the Biological Opinion and from the USACE and Water Agency staff regarding RPAs related to the estuary, Dry Creek, D1610 and public outreach.

Community Meetings (Healdsburg, November 5, 2008; Guerneville, November 6, 2008; Ukiah, November 13, 2008; and Jenner, November 19, 2008) – Each community meeting included a review of the basic components of the Biological Opinion, plus a focused discussion on the RPAs particularly relevant to that community. For example, in Guerneville, the focus was on proposed changes to D1610 and in Jenner the focus was on estuary adaptive management. Presenters included staff from NMFS, DFG and the Water Agency. These meetings were advertised in community newspapers and through press releases. Attendance ranged from about 80 (Guerneville) to approximately 30 (Healdsburg).

Community Meetings, Temporary Urgency Changes – Meetings were held in Guerneville, Windsor and Ukiah in Spring 2009, informing residents of the Water Agency's petition to the State Water Board for temporary reductions in minimum instream flows.

Community Meetings, Dry Creek – Two meetings were held in Healdsburg on March 19 to discuss in further detail the pipeline feasibility study and the habitat enhancement study. A total of about 50 people attended the meetings, most from the Dry Creek area.

Community Meeting, Jenner – A meeting was held on June 22, 2009 in Jenner. The purpose of the meeting was to educate residents about the need for changes to the estuary and to inform them about monitoring, studies and other activities. Speakers included staff from NMFS, DFG and the Water Agency.

Stakeholder Assessment

The Water Agency engaged the Center for Collaborative Policy to conduct a stakeholder assessment of issues raised in the Biological Opinion. The center found that while many stakeholders were open to the mandates of the Biological Opinion and understood the need for changes, Dry Creek landowners and agricultural interests were skeptical. The Center recommended that the Water Agency create a Dry Creek stakeholders group to educate landowners on the Biological Opinion and to solicit their input on the habitat enhancement and pipeline studies.

A Dry Creek stakeholders group comprised of landowners and representatives from the Water Agency, the USACE, NMFS and DFG was created and met four times in 2009.

Other outreach

Free Media – Several articles about the Biological Opinion appeared in The Press Democrat, the Healdsburg Tribune, the North Bay Business Journal, the Russian River Times, the West County News and Review, and the Russian River Gazette.

Electronic Media – The Water Agency created a webpage for information about the Biological Opinion. The page includes electronic versions of the Biological Opinion, background materials, meeting information and presentations and links to videos. The Water Agency also created email lists of people interested in updates on specific issues (i.e. the estuary and Dry Creek).

Materials – The Water Agency developed and published a series of five briefing papers that clearly and succinctly explained key aspects of the Biological Opinion. These materials were distributed at meetings, conferences, outreach events, and through the Water Agency website.

Water Agency Public Outreach Activities – 2009

Meetings

Public Policy Facilitating Committee meeting, October 18, 2009 – The PPFC received an update on Year 1 activities and a preview of Year 2. Notices for the meeting were sent out to approximately 1,000 individuals and agencies and it was advertised in The Press Democrat and community newspapers. Approximately 50 people attended the meeting and heard presentations from NMFS, DFG and Water Agency staff.

Community Meetings, Temporary Urgency Changes – Meetings were held in Guerneville, Healdsburg and Ukiah in Spring 2010 informing residents of the Water Agency's petition to the State Water Board for temporary reductions in minimum instream flows. Speakers included staff from NMFS, DFG and the Water Agency. The meetings were attended by a total of about 100 people.

Community Meeting, Dry Creek – Invitations were sent to all property owners in Dry Creek (approximately 400 landowners) to attend a January 27, 2010 meeting at Dry Creek Vineyards to learn about the habitat enhancement and pipeline feasibility studies and to answer questions regarding requests for access (required by studies). Approximately 50 people attended.

Community Meeting, Jenner – A meeting was held on May 19, 2010 in Jenner, to update residents on studies and upcoming summer activities in the estuary. Speakers included staff from NMFS and the Water Agency.

Scoping Meetings, Outlet Channel Adaptive Management – A scoping meeting on the Notice of Preparation for the EIR on Outlet Channel Adaptive Management plan was held on May 19, 2010, immediately following the community meeting. A second scoping meeting was held on May 20 in Santa Rosa. A total of approximately 110 people attended the meetings.

Stakeholder Assessment

The Dry Creek stakeholder group met three times, and provided input on the Dry Creek habitat enhancement study and the Dry Creek pipeline feasibility study. The group was led on a walking tour of a possible habitat enhancement site by property owner Don Wallace and Inter Fluve consultant Mike Burke.

Approximately 60 percent of Dry Creek property owners who were sent letters requesting temporary access of habitat enhancement studies in 2010 granted the Water Agency's request.

Other outreach

Free Media – Several articles about the Biological Opinion appeared in The Press Democrat, the Healdsburg Tribune, the Russian River Times, the West County News and Review, and the Russian River Gazette. Press releases were issued on all community meetings, the estuary scoping document, temporary urgency changes, and the D1610 notice of preparation (Appendices A-1 to A-5).

Electronic Media – The Water Agency continually updated its Biological Opinion webpage, including links on new documents and meetings. In addition, the Water Agency is producing (internally) a series of videos explaining specific aspects of the Biological Opinion. These videos, which are posted on YouTube, can be accessed via the agency's website. Email alerts regarding activities in the estuary were issued 12 times in Year 2.

Materials – The Water Agency rewrote and redesigned its briefing papers to reflect new information and studies being conducted. These materials were distributed at meetings, conferences, statewide forums, outreach events and through the Water Agency website. In addition, a simple postcard handout was developed for events geared to the general public.

Sonoma County Fair – The Biological Opinion was the focus of the Water Agency's outreach efforts at the Sonoma County Fair. In order to get a free gift (a reusable grocery bag), attendees needed to take a short "quiz" focused on aspects of the Biological Opinion (questions included "Name one of three fish in the Russian River that is on the endangered species list?" "Why are we asking people to conserve water this summer, even though we aren't in a drought?" "Why is Dry Creek important to your water supply?" and "Can you tell us what an estuary is and whether the Russian River has one?") These questions provided staff an opportunity to discuss the Biological Opinion with approximately 2,000 people.

3: Pursue Changes to Decision 1610 Flows

Two major reservoir projects provide water supply storage in the Russian River watershed: 1) Coyote Valley Dam/Lake Mendocino, located on the East Fork of the Russian River three miles east of Ukiah, and 2) Warm Springs Dam/Lake Sonoma, located on Dry Creek 14 miles northwest of Healdsburg. The Water Agency is the local sponsor for these two federal water supply and flood control projects, collectively referred to as the Russian River Project. Under agreements with the United States Army Corps of Engineers (USACE), the Water Agency manages the water supply storage space in these reservoirs to provide a water supply and maintain summertime Russian River and Dry Creek streamflows.

The Water Agency holds water-right permits[1] issued by the State Water Resources Control Board (SWRCB) that authorize the Water Agency to divert[2] Russian River and Dry Creek flows and to re-divert[3] water stored and released from Lake Mendocino and Lake Sonoma. The Water Agency releases water from storage in these lakes for delivery to municipalities, where the water is used primarily for residential, governmental, commercial, and industrial purposes. The primary points of diversion include the Water Agency's facilities at Wohler and Mirabel Park (near Forestville). The Water Agency also releases water to satisfy the needs of other water users and to contribute to the maintenance of minimum instream flow requirements in the Russian River and Dry Creek established in 1986 by the SWRCB's Decision 1610. These minimum instream flow requirements vary based on defined hydrologic conditions (normal, dry, and critical) that are based on cumulative inflows into Lake Pillsbury in the Eel River watershed.

NMFS concluded in the Russian River Biological Opinion that the artificially elevated summertime minimum flows in the Russian River and Dry Creek that are currently required by Decision 1610 result in high water velocities that reduce the quality and quantity of rearing habitat for coho salmon and steelhead. NMFS' Russian River Biological Opinion concludes that reducing Decision 1610 minimum instream flow requirements will enable alternative flow management scenarios that will increase available rearing habitat in Dry Creek and the upper Russian River, and provide a lower, closer-to-natural inflow to the estuary between late spring and early fall, thereby enhancing the potential for maintaining a seasonal freshwater lagoon that would likely support increased production of juvenile steelhead and salmon.

[1] SWRCB water-right permits 12947A, 12949, 12950 and 16596.
[2] Divert – refers to water diverted directly from streamflows into distribution systems for beneficial uses or into storage in reservoirs.
[3] Re-divert – refers to water that has been diverted to storage in a reservoir, then is released and diverted again at a point downstream.

Changes to Decision 1610 are under the purview of the State Water Resources Control Board (SWRCB), which retained under Decision 1610 the jurisdiction to modify minimum instream flow requirements if future fisheries studies identified a benefit. NMFS recognized that changing Decision 1610 would require a multi-year (6 to 8 years) process of petitioning the SWRCB for changes to minimum instream flow requirements, public notice of the petition, compliance with the California Environmental Quality Act (CEQA), and a SWRCB hearing process. To minimize the effects of existing minimum instream flows on listed salmonids during this process, the Russian River Biological Opinion stipulated that the Water Agency "will seek both long term and interim changes to minimum flow requirements stipulated by D1610." The permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion are summarized in Figure 3.1.

Permanent Changes

The Russian River Biological Opinion requires the Water Agency to begin the process of changing minimum instream flows by submitting a petition to change Decision 1610 to the SWRCB within one year of the date of issuance of the final Biological Opinion. The requested changes to instream flow requirements are to be reduced in the mainstem Russian River and Dry Creek between late spring and early fall during normal and dry water years and promote the goals of enhancing salmonid rearing habitat in the upper Russian River mainstem, lower river in the vicinity of the Estuary, and Dry Creek downstream of Warm Springs Dam. NMFS' Russian River Biological Opinion concluded that, in addition to providing fishery benefits, the lower instream flow requirements "should promote water conservation and limit effects on in-stream river recreation." NMFS stated that the following changes, based on observations during the 2001 interagency flow-habitat study and the 2007 low flow season, may achieve these goals:

During Normal Years:

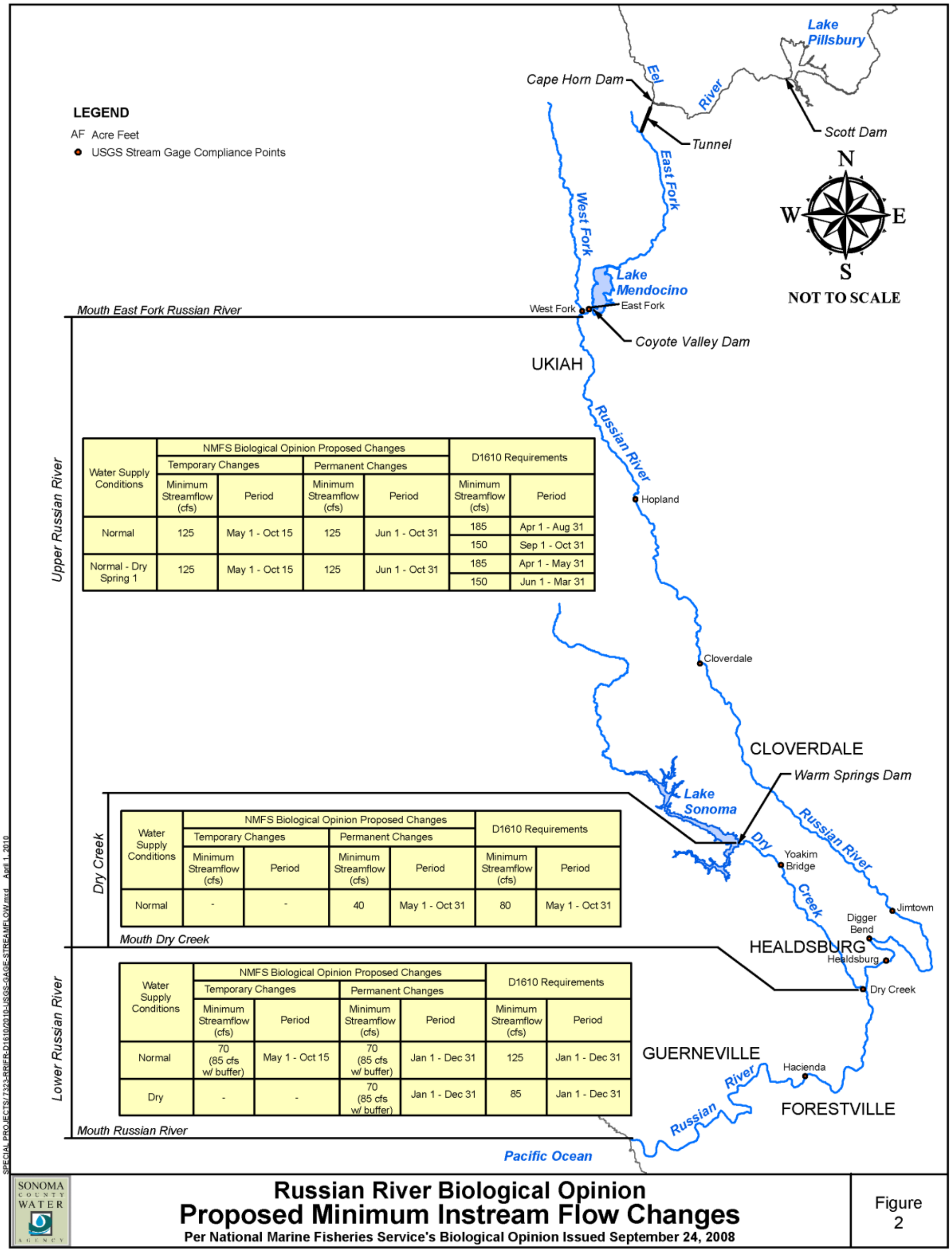
1. Reduce the minimum flow requirement for the Russian River from the East Fork to Dry Creek from 185 cfs to 125 cfs between June 1 and August 31; and from 150 cfs to 125 cfs between September 1 and October 31.
2. Reduce the minimum flow requirement for the Russian River between the mouth of Dry Creek and the mouth of the Russian River from 125 cfs to 70 cfs.
3. Reduce the minimum flow requirement for Dry Creek from Warm Springs Dam to the Russian River from 80 cfs to 40 cfs from May 1 to October 31.

During Dry Years:

1. Reduce the minimum flow requirement for the Russian River between the mouth of Dry Creek and the mouth of the Russian River from 85 cfs to 70 cfs.

Summary Status

As required by NMFS' Russian River Biological Opinion, on September 23, 2009, the Water Agency filed a petition with the SWRCB to permanently change the Decision 1610 minimum instream flow requirements, in order to improve habitat for endangered Central California



Upper Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Temporary Changes – Period	Permanent Changes – Minimum Streamflow (cfs)	Permanent Changes – Period	D1610 Requirements: Minimum Streamflow (cfs)	D1610 Requirements: Period
Normal	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - Aug 31
					150	Sep 1 - Oct 31
Normal - Dry Spring 1	125	May 1 - Oct 15	125	Jun 1 - Oct 31	185	Apr 1 - May 31
					150	Jun 1 - Mar 31

Dry Creek

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Temporary Changes – Period	Permanent Changes – Minimum Streamflow (cfs)	Permanent Changes – Period	D1610 Requirements: Minimum Streamflow (cfs)	D1610 Requirements: Period
Normal	-	-	40	May 1 - Oct 31	80	May 1 - Oct 31

Lower Russian River

Water Supply Conditions	NMFS Biological Opinion Proposed Changes: Temporary Changes – Minimum Streamflow (cfs)	Temporary Changes – Period	Permanent Changes – Minimum Streamflow (cfs)	Permanent Changes – Period	D1610 Requirements: Minimum Streamflow (cfs)	D1610 Requirements: Period
Normal	70 (85 cfs w/ buffer)	May 1 - Oct 15	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	125	Jan 1 - Dec 31
Dry	-	-	70 (85 cfs w/ buffer)	Jan 1 - Dec 31	85	Jan 1 - Dec 31

Figure 3.1. A summary of the permanent and temporary changes to Decision 1610 minimum instream flow requirements specified by NMFS in the Russian River Biological Opinion.

Coast coho salmon and threatened Central California Coast steelhead. This petition is pending before the SWRCB. A copy of the petition is provided in Appendix B-1.

Temporary Changes

Until the SWRCB issues an order on the petition described above, the minimum instream flow requirements specified in Decision 1610 (with the resulting adverse impacts to listed salmonids) will remain in effect, unless temporary changes to these requirements are made by the SWRCB. NMFS' Russian River Biological Opinion requires that the Water Agency petition the SWRCB for temporary changes to the Decision 1610 minimum instream flow requirements beginning in 2010 and for each year until the SWRCB issues an order on the Water Agency's petition for the permanent changes to these requirements. NMFS' Russian River Biological Opinion only requires that petitions for temporary changes "request that minimum bypass flows of 70 cfs be implemented at the USGS gage at the Hacienda Bridge between May 1 and October 15, with the understanding that for compliance purposes SCWA will typically maintain about 85 cfs at the Hacienda gage. For purposes of enhancing steelhead rearing habitats between the East Branch and Hopland, these petitions will request a minimum bypass flow of 125 cfs at the Healdsburg gage between May 1 and October 15."

Summary Status

The Water Agency petitioned the SWRCB for temporary changes to Decision 1610 on April 6, 2009, in response to unusually low storage in Lake Mendocino. Although Lake Mendocino storage was low due to a dry spring, inflow into Lake Pillsbury during the water year was sufficiently high enough to classify 2009 as a *Normal* year under Decision 1610. The water year classifications (*Normal, Dry or Critical*) specified in Decision 1610 are based on cumulative inflow into Lake Pillsbury beginning October 1. Consequently, the Water Agency filed a Temporary Urgency Change Petition (TUCP) to request that the SWRCB reduce the minimum instream flow requirements for the Russian River in the Water Agency's water-right permits, to maintain sufficient storage in Lake Mendocino so that it would not dry up during the fall of 2009.

Low Lake Mendocino storage levels could severely impact listed and threatened Russian River fish species, create serious water-supply impacts in Mendocino County and the Alexander Valley in Sonoma County, and harm Lake Mendocino and Russian River recreation. The Water Agency requested that the SWRCB make the following temporary changes to the Decision 1610 instream flow requirements:

- for April 6 through June 30, the Decision 1610 requirements for *Dry* conditions will apply in the Russian River (these requirements are 75 cfs in the Upper Russian River (from its confluence with the East Fork to its confluence with Dry Creek) and 85 cfs in the Lower Russian River (downstream of its confluence with Dry Creek);
- if, during the period from April 1 through June 30, total inflow into Lake Mendocino is less than or equal to 25,000 AF, then, for July 1 through October 2, the Decision 1610 requirements for *Critical* conditions will apply in the Russian River (these requirements are 25 cfs in the Upper Russian River (from its confluence with the

East Fork to its confluence with Dry Creek) and 35 cfs in the Lower Russian River (downstream of its confluence with Dry Creek); and

- if, during the period from April 1 through June 30, 2009, total inflow into Lake Mendocino is greater than 25,000 AF, then, for July 1 through October 2, the Decision 1610 requirements for *Dry* conditions will apply in the Russian River.

The SWRCB issued Order WR 2009-0027-DWR approving the Water Agency's TUCP on April 10, 2009 (Appendix B-2). The SWRCB held a public workshop on the Temporary Urgency Change (TUC) Order on May 6, 2009 (Appendix B-2, notice of workshop). A revised order (Order WR 2009-034_EXEC) was issued on May 28, 2009, and extended through October 2, 2009 (Appendix B-3). The revised order included several terms and conditions for the TUC, including requirements for implementation of fisheries habitat (Term 6, Appendix B-4) and water quality monitoring (Term 7, Appendix B-5) plans, and development of water conservation (Term 15, Appendix B-6), and water rights accounting plans (Term 18) (Appendix B-7).

During summer and early fall 2009, Water Agency biologists conducted habitat, juvenile fish, and adult fish surveys in the mainstem Russian River to document the effects of flow reduction per State Board Order WR 2009 – 0034 EXEC. Sampling locations and methods were guided by a monitoring plan that was approved by the National Marine Fisheries Service and California Department of Fish and Game (Appendix B-4). Data collection efforts during summer focused on rearing habitat for juvenile fish. Efforts to document changes to physical habitat focused on seven reaches of the mainstem Russian River between Ukiah and Mirabel. Specific locations overlapped spatially with fish monitoring sites. Habitat surveys were conducted in June, before flow reduction, and in August when the Order was being implemented. Snorkeling using multiple divers in 500-m-long reaches was used to assess fish populations. A total of 12 sites were surveyed between August 17 and 25, 2009. Starting September 1, 2009, Chinook salmon presence in areas downstream and upstream of Mirabel Dam was evaluated by divers. These dive surveys were to continue until 200 adult Chinook salmon passed Mirabel Dam or until the Fisheries Monitoring Plan expired on October 2, 2009. During the early migration season, three lower River sites were sampled weekly, including Vacation Beach Dam, Johnson's Beach Dam, and Mirabel Dam. To assess potential habitat conditions at lower flow, a site at Geyserville was sampled every two weeks during the early season. After 200 salmon passed Mirabel Dam, effort was to shift to upstream sites at Mirabel Dam, Healdsburg Dam, Digger's Bend, and Geyserville. However, this sampling scheme was not implemented because 200 adult salmon did not pass Mirabel Dam prior to October 2, 2009. Detailed results are provided in the Results of the Fisheries Monitoring Plan to Meet State Water Resources Control Board Order WR 2009 – 0034 Exec (Water Agency 2009, Appendix B-8).

During the term of the TUC order, real time water quality data (pH, temperature, dissolved oxygen content, specific conductivity, turbidity, and depth) was monitored at 16 locations along the Russian River using YSI Sondes. In addition, over 300 bacteriological samples (total coliform, *E. coli* and Enterococcus) and 130 nutrient samples (Ammonia-N; Nitrate-N; Total Organic Nitrogen; Total Phosphorous; and chlorophyll-a) were collected between May 28 and October 2 at the same locations. Monitoring results were posted to the Water Agency website as soon as the results were received. A summary report and the monitoring results are provided in Appendix B-9

Order WR 2009 – 0034 Exec also included water conservation requirements for the Water Agency contractors, as well as a requirement for the development of a water rights accounting plan. These plans and summary reports are provided in Appendix B-10.

In addition to the terms and conditions above, the Water Agency engaged recreational business owners in a discussion of potential effects of lower minimum instream flow requirements on boating (primarily kayaking and canoeing) passage (see Public Outreach Chapter). The Water Agency prepared a Russian River Recreation Assessment. An assessment of impacts to recreation activities in the Russian River was not a required monitoring element of the TUC; however, the Water Agency recognized that the Russian River is heavily utilized as a recreation resource and voluntarily undertook an assessment of how the lower flows under the TUC may have impacted the ability of people to utilize the Russian River for recreational activities. Water Agency staff took before and after measurements at various riffle points between Rio Linda (approximately 5 river miles upstream of Healdsburg Memorial Beach) and Cassini Ranch (approximately 3 river miles downstream of Monte Rio) to compare water depth changes between the higher Russian River flows in June of 2009 with the lower flows that occurred under the TUC between July and October 2009. A copy of the Russian River Recreation Assessment is available at the Water Agency's website:
http://www.scwa.ca.gov/files/docs/conservation/stateboard2009/2009-TUCP-RecreationAssessment-Report.pdf

4: Estuary Management

The Russian River estuary (Estuary) is located approximately 97 kilometers (km; 60 miles) northwest of San Francisco in Jenner, Sonoma County, California. The Russian River watershed encompasses 3,847 square kilometers (km) (1,485 square miles) in Sonoma, Mendocino, and Lake Counties. The Estuary extends from the mouth of the Russian River upstream approximately 10 to 11 km (6 to 7 miles) between Austin Creek and the community of Duncans Mills (Heckel 1994).

The Estuary may close throughout the year as a result of a barrier beach forming across the mouth of the Russian River. The mouth is located at Goat Rock State Beach (California Department of Parks and Recreation). Although closures may occur at anytime of the year, the mouth usually closes during the spring, summer, and fall (Heckel 1994; Merritt Smith Consulting 1997, 1998, 1999, 2000; Sonoma County Water Agency and Merritt Smith Consulting 2001). Closures result in ponding of the Russian River behind the barrier beach and, as water surface levels rise in the Estuary, flooding may occur. The barrier beach has been artificially breached for decades; first by local citizens, then the County of Sonoma Public Works Department, and, since 1995, by the Water Agency. The Water Agency's artificial breaching activities are conducted in accordance with the Russian River Estuary Management Plan recommended in the Heckel (1994) study. The purpose of artificially breaching the barrier beach is to alleviate potential flooding of low-lying properties along the estuary.

NMFS' Russian River Biological Opinion (NMFS 2008) found that artificially elevated inflows to the Russian River estuary during the low flow season (May through October) and historic artificial breaching practices have significant adverse effects on the Russian River's estuarine rearing habitat for steelhead, coho salmon, and Chinook salmon. The historic method of artificial sandbar breaching, which is done in response to rising water levels behind the barrier beach, adversely affects the estuary's water quality and freshwater depths. The historic artificial breaching practices create a tidal marine environment with shallow depths and high salinity. Salinity stratification contributes to low dissolved oxygen at the bottom in some areas. The Biological Opinion (NMFS 2008) concludes that the combination of high inflows and breaching practices impact rearing habitat because they interfere with natural processes that cause a freshwater lagoon to form behind the barrier beach. Fresh or brackish water lagoons at the mouths of many streams in central and southern California often provide depths and water quality that are highly favorable to the survival of rearing salmon and steelhead.

The Biological Opinion's Reasonable and Prudent Alternative (RPA) 2, Alterations to Estuary Management, (NMFS 2008) requires the Water Agency to collaborate with NMFS and to modify estuary water level management in order to reduce marine influence (high salinity and tidal inflow) and promote a higher water surface elevation in the estuary (formation of a fresh or brackish lagoon) for purposes of enhancing the quality of rearing habitat for young-of-year and age 1+ juvenile (age 0+ and 1+) steelhead from May 15 to October 15 (referred to hereafter as the “lagoon management period”). A program of potential, incremental steps are prescribed to accomplish this, including adaptive management of a lagoon outlet channel on the barrier beach, study of the existing jetty and its potential influence on beach formation processes and salinity seepage through the barrier beach, and a feasibility study of alternative flood risk measures. RPA 2 also includes provisions for monitoring the response of water quality, invertebrate production, and salmonids in the estuary to the management of water surface elevations during the lagoon management period.

RPA 2 required the Water Agency, with support from NMFS, to conduct public outreach and education on the need to reduce estuarine impacts by avoiding mechanical breaching to the greatest extent possible within the first 6 months following release of the Russian River Biological Opinion. Please see the Public Outreach Chapter in this report, for details regarding the Water Agency’s public outreach efforts regarding the Russian River Biological Opinion and Estuary Management. The following section provides a summary of the Water Agency’s estuary management actions required under the Russian River Biological Opinion RPA 2 in 2009.

Sandbar Management

RPA 2 requires the Water Agency, in coordination with NMFS, CDFG, and the USACE, to annually prepare barrier beach outlet channel design plans. Each year after coordinating with the agencies, the Water Agency is to provide a draft plan to NMFS, CDFG, and the USACE by April 1 for their review and input. The initial plan was to entail the design of a lagoon outlet channel cut diagonally to the northwest. Sediment transport equations shall be used by Water Agency as channel design criteria to minimize channel scour at the anticipated rate of Russian River discharge. This general channel design will be used instead of traditional mechanical breaching whenever the barrier beach closes and it is safe for personnel and equipment to work on the barrier beach. Alternate methods may include 1) use of a channel cut to the south if prolonged south west swells occur, and 2) use of the current jetty as a channel grade control structure (as described below) for maintaining water surface elevations up to 7-9 feet NGVD (NMFS 2008).

The Water Agency contracted with Philip Williams and Associates (PWA) to prepare the Russian River Estuary Outlet Channel Adaptive Management Plan Year 1 (PWA 2009, Appendix C-1). The approach of the Year 1 plan was to meet the objective of RPA 2 to the greatest extent feasible while staying within the constraints of existing regulatory permits and minimizing the impact to aesthetic and recreational resources of the site. It was recognized that the measures developed in the Year 1 management plan, when implemented, potentially could not fully meet the objectives established by the RPA due to the permitting constraints. The concept of this approach was developed in coordination with NMFS. Permitting constraints (see Permitting below) required the implementation of the outlet channel adaptive plan to be delayed in 2009.

A monthly topographic survey of the beach at the mouth of the Russian River is also required under RPA 2. Due to permitting constraints (see Permitting below), not all scheduled surveys were completed in 2009. The beach topographic maps are provided in Appendix C-2.

The Water Agency contracted with Environmental Data Solutions (EDS) to design and conduct a field data collection program within the Estuary to produce a 2-foot interval contour map of the river channel and surrounding topography. The project area was bounded by the river mouth downstream in Jenner and by Austin Creek upstream near Duncans Mills. The 7.2 mile study reach also included the Willow Creek watershed on river left, 0.40 miles upstream from the Highway 1 Bridge. EDS collected high-resolution bathymetric data, sidescan imagery data, bottom sediment sample data, water surface elevation time series data (WSE) and topographic data. In addition, the Water Agency contracted with Delta Geomatics, Inc. to collect LiDAR data from the center of the river out to the floodplain on the north and south sides of the river. The LiDAR and bathymetric data sets were used to generate the bathymetry contour maps (Figure 4.1).

Artificial breaching activities to minimize flood risk in the Estuary were implemented as necessary in 2009. The number of sandbar closures was unusually high in 2009, with 13 closures total. Twelve of the closures and subsequent breaching events occurred outside the lagoon management period (May 15 to October 15).

Table 4.1: Summary of Russian River estuary sandbar closures in 2009.

Date Closed	Date Breached	Height when breached	Type of Breach
5-Jan	8-Jan	5.3	Natural
?	22-Jan		Water Agency
13-Apr	16-Apr	5.8	Natural
12-Jun	25-Jun	6.4	Water Agency
6-Sep	5-Oct	7.3	Water Agency
14-Oct	16-Oct	7.7	Water Agency
22-Oct	26-Oct	6.8	Water Agency
2-Nov	9-Nov	7.6	Water Agency
	10-Nov	8.1	Second attempt successful
11/18-11/21	23-Nov	6.9	Water Agency
	24-Nov	7.5	Second attempt successful
11/25-11/27	2-Dec	7.5	Water Agency
8-Dec	13-Dec	9	Water Agency
21-Dec	23-Dec	8.2	Water Agency
25-Dec	28-Dec	9.1	Water Agency

Jetty

RPA 2 includes a second step if adaptive management of the outlet channel as described, “is not able to reliably achieve the targeted annual and seasonal estuary management water surface elevations by the end of 2010, Water Agency will draft a study plan for analyzing the effects and role of the Russian River jetty at Jenner on beach permeability, seasonal sand storage and transport, seasonal flood risk, and seasonal water surface elevations in the Russian River estuary. That study will also evaluate alternatives for achieving targeted estuarine management water surface elevations via jetty removal, partial removal of the jetty, jetty notching, and potential use of the jetty as a tool in maintaining the estuary water surface elevations described above."

No additional work on the jetty study plan was performed or required in 2009.

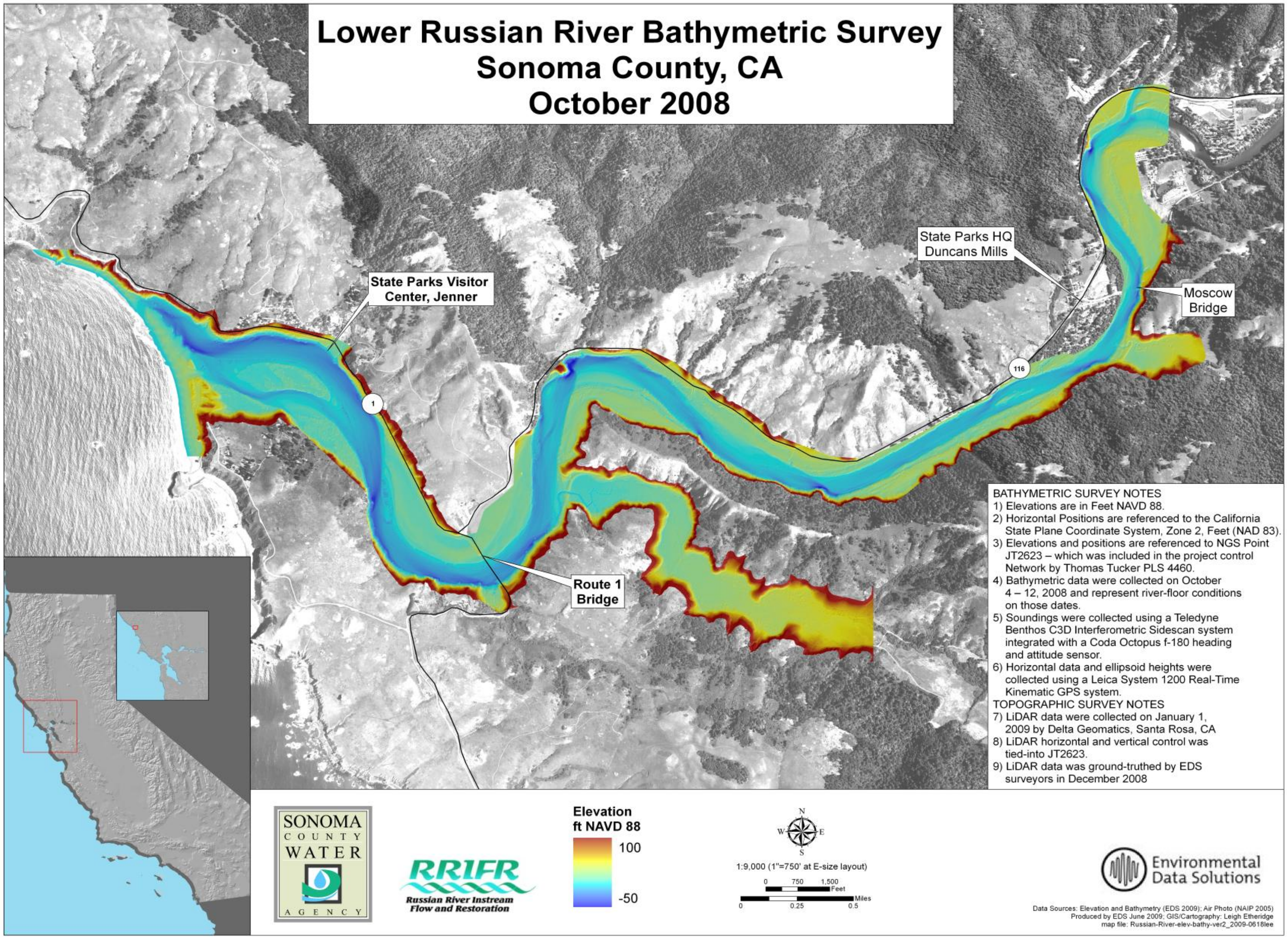


Figure 4.1 Lower Russian River bathymetric survey conducted during October 2008.

Flood Risk Management

RPA 2 also includes a Flood Risk Reduction step if it proves difficult to reliably achieve raised water surface elevation targets based on implementation of a lagoon outlet channel or modification of the existing jetty. Should those actions be unsuccessful in meeting estuarine water surface elevation goals, RPA 2 states that the Water Agency "will evaluate, in coordination with NMFS and other appropriate public agencies, the feasibility of actions to avoid or mitigate damages to structures in the town of Jenner and lowlying properties along the estuary that are currently threatened with flooding and prolonged inundation when the barrier beach closes and the estuary's water surface elevation rises above 9 feet. Such actions may include, but are not limited to, elevating structures to avoid flooding or inundation."

The first effort in the flood risk feasibility effort, a list of structures, properties, and infrastructure that would be subject to flooding/inundation as the result of sandbar formation and if the estuary were allowed to naturally breach was not due until 18 months after the issuance of the Russian River Biological Opinion (March 2010). Therefore, no additional work on flood risk management was performed or required in 2009.

Permitting

In addition to compliance with the federal and California Endangered Species Acts, water level and beach management activities in the Estuary require compliance with numerous other federal and state regulations, as well as leases from several state agencies to perform management activities at Goat Rock State Beach and in the Russian River estuary. At the time of issuance of the Russian River Biological Opinion,[4] the Water Agency held permits for artificial breaching from California State Parks, California State Lands Commission, California Coastal Commission, North Coast Regional Water Quality Board, California Department of Fish and Game, and the U.S. Army Corps of Engineers. Beginning in late 2008, the Water Agency began working with these state and federal agencies to either modify or receive clarification regarding the scope of activities allowed under existing permits to allow for creation of the lagoon outlet channel and compliance with RPA 2 of the Russian River Biological Opinion. Existing permits were either modified or clarification received to allow creation of the lagoon outlet channel, with the exception of the California Coastal Commission's Coastal Development Permit, which was modified in 2010.

Following issuance of the Russian River Biological Opinion, the Water Agency was informed that a permit was also required under the Marine Mammal Protection Act (MMPA) as beach management activities occurred in the vicinity of a harbor seal haulout at the mouth of the Russian River. The Water Agency applied to NMFS for an Incidental Harassment Authorization (IHA) under the MMPA in 2009. The application process was ongoing in 2009, including public notice and comment in the Federal Register. A final IHA was issued in 2010. As this permit was

[4] The previous NMFS biological opinion specific to estuary breaching activities was replaced with the Russian River Biological Opinion.

required for all beach management activities, the Water Agency was unable to implement the lagoon outlet management plan or to perform beach topographic surveys in 2009.

4.1 Water Quality Monitoring

Water quality monitoring was conducted in the lower, middle, and upper reaches of the Russian River Estuary between the mouth of the river at Jenner and Freezeout Creek in Duncans Mills. Water Agency staff continued to collect data to establish baseline information on water quality in the Estuary, gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide, and track changes to the water quality profile that may occur during periods of barrier beach closure and reopening.

Saline water is denser than freshwater and a salinity “wedge” forms as freshwater outflow passes over the denser tidal inflow. During the Lagoon Management Period, the lower and middle reaches of the Estuary up to Sheephouse Creek are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates upstream to Duncans Mills during summer low flow conditions and barrier beach closure. Additionally, river flows, tides, topography, and wind action affect the amount of mixing of the water column at various longitudinal and vertical positions within the Estuary.

In 2009, the Estuary experienced its longest closure since the Water Agency began monitoring and managing the river mouth for flood control purposes. The barrier beach formed and the Estuary closed for a period of 29 days from 6 September to 5 October. During this time the Agency was able to monitor the partial development of a freshwater lagoon system as freshwater inflows increased the surface layer to approximately 9 feet thick and the volume of denser saltwater in the lower layer of the water column began to decline as it seeped through the barrier beach.

Methods

Continuous Multi-Parameter Monitoring

Water quality was monitored using YSI Series 6600 multi-parameter datasondes. Hourly salinity (parts per thousand), water temperature (degrees Celsius), dissolved oxygen (milligrams per liter), and pH (hydrogen ion) data were collected. Datasondes were cleaned and recalibrated periodically following the YSI User Manual procedures, and data was downloaded during each calibration event.

Six stations were established for continuous water quality monitoring (Figure 4.1.1). One station was located in the lower reach at the mouth of the Russian River at Goat Rock State Beach (Mouth Station). Three stations were placed in the middle reach: Patty’s Rock upstream of Penny Island (Patty’s Rock Station); Bridgehaven just downstream from the Highway 1 Bridge

(Bridgehaven Station); and in the pool downstream of Sheephouse Creek (Sheephouse Creek Station). Two stations were located in the upper reach; a pool next to an area known as Heron Rookery located halfway between Sheephouse Creek and Duncans Mills (Heron Rookery Station), and downstream of Freezeout Creek in Duncans Mills (Freezeout Creek Station). The rationale for choosing these sites was to locate the deepest holes at various points throughout the Estuary to obtain the fullest vertical profiles possible, and to monitor hypoxic and/or anoxic events and temperature or salinity stratification.

Monitoring stations were comprised of a concrete anchor attached to a steel cable suspended from the surface by a large buoy (Figure 4.1.2). All stations had a vertical array of two datasondes to collect water quality profiles. Stations in the lower and middle reaches of the Estuary that are predominantly saline had sondes placed at the surface (~1m) and mid-depth (~3m) portions of the water column. The two stations in the upper reach of the Estuary, where water is predominantly fresh to brackish, were located in the lower half of the water column at mid-depth (~3-4m) and the bottom (~5-7m). Sondes were located in this manner to track vertical and longitudinal changes in water quality characteristic.

Monitoring at the Mouth, Heron Rookery, Freezeout, Patty's Rock, and Sheephouse stations was conducted between the third week of April and first week of December, 2009. The Bridgehaven station was operated from late May to early December.

Grab Sample Collection

Three stations were established in 2009 for nutrient and indicator bacteria grab sampling: the Jenner Boat Ramp (Jenner Station), Bridgehaven at the mouth of Willow Creek (Bridgehaven Station), and at the Moscow Road Bridge in Duncans Mills (Duncans Mills Station). Water Agency staff collected grab samples once every three weeks from 28 May to 1 October. Nutrient samples were analyzed at Alpha Labs in Ukiah and bacterial samples were analyzed at the Sonoma County Department of Health Services (DHS) labs in Santa Rosa. Nutrient sampling was conducted for total organic nitrogen, ammonia, nitrate, and total phosphorus, as well as for *chlorophyll a*, which is a measurable parameter of algal growth that can be tied to excessive nutrient concentrations. Sampling was also conducted for indicator bacteria including total coliforms, *Enterococcus*, and *E. coli*. These bacteria are indicators of water quality conditions that may be a concern for water contact recreation and public health.

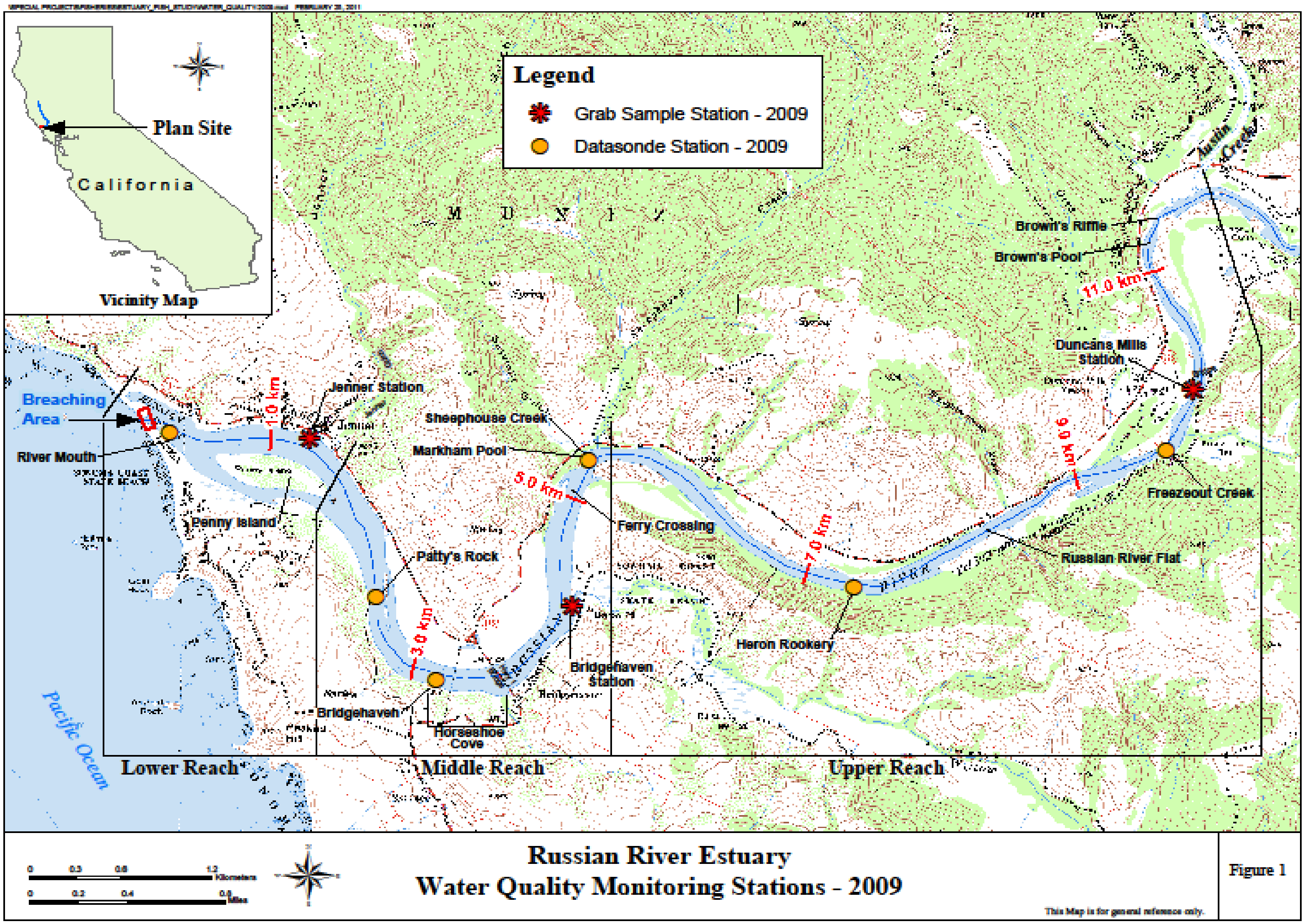


Figure 4.1.1. 2009 Russian River Estuary Water Quality Monitoring Stations

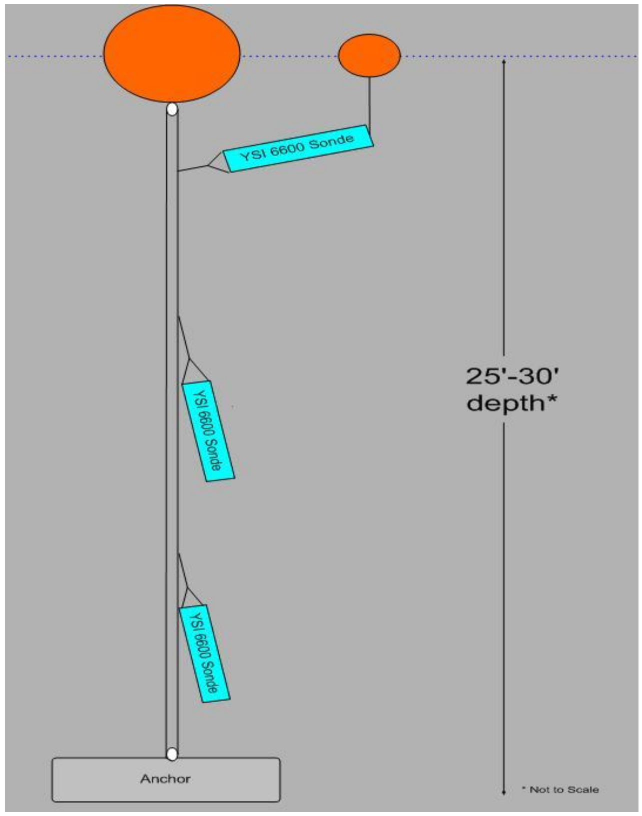


Figure 4.1.2. Typical Russian River Estuary monitoring station datasonde array.

Results

With the exception of an extended barrier beach closure period lasting 29 days from September 6 through October 5, water quality conditions in 2009 were similar to trends observed in sampling from 2004 to 2008. The lower and middle reaches are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater layer. The upper reach transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates up and downstream and appears to be affected in part by freshwater inflow rates, tidal inundation, barrier beach closure, and subsequent tidal cycles following reopening of the barrier beach. The lower and middle reaches of the Estuary are subject to tidally-influenced fluctuations in water depth and inundation during barrier beach closure, as is the upper reach to a lesser degree.

Table 4.1.1 presents a summary of minimum, mean, and maximum values for temperature, depth, dissolved oxygen (DO), pH, and salinity recorded at the various datasonde monitoring stations. Data associated with malfunctioning datasonde equipment has been removed from the data sets, resulting in the data gaps observed in the graphs presented as Figures 4.1.3 through 4.1.26. These data gaps may affect minimum, mean, and maximum values of the various monitored constituents, including at the Mouth Mid-Depth Sonde from mid-August to mid-October, the Bridgehaven Surface Sonde from early October to early November, the

Sheephouse Creek Surface Sonde during the first half of June, the Heron Rookery Bottom Sonde from late April to late July, several malfunctions at the Freezeout Creek Bottom Sonde from July to October, and most significantly at the Patty's Rock Surface Sonde for most of season after June and July. The majority of malfunctions were associated with DO data, especially in anoxic water; however malfunctions of the other constituent probes, including temperature, also occurred. Although gaps exist in the 2009 data that affect sample statistics, Agency staff has collected long time-series data on an hourly frequency for several years, and it is unlikely that the missing data appreciably affected the broader understanding of water quality conditions within the estuary.

Table 4.1.1. Russian River estuary 2009 water quality monitoring results. Minimum, mean, and maximum temperature (degrees C), depth (m), dissolved oxygen (mg/L), hydrogen ion (pH), and salinity (ppt).

Monitoring Station *Sonde*	Temperature (°C)	Depth (m)	Dissolved Oxygen (%) saturation	Dissolved Oxygen (mg/L)	Hydrogen Ion (pH)	Salinity (ppt)
Mouth						
Surface						
April 20 - December 7						
Min	7.9	0.7	40.5	3.4	7.3	0.2
Mean	15.0	0.9	117.5	10.8	8.1	15.0
Max	**22.2**	**1.0**	**500.0**	**46.3**	**9.1**	**33.7**
Mid-Depth						
April 20 - December 7						
Min	8.7	2.1	4.0	0.4	7.5	0.2
Mean	12.3	2.9	80.7	7.4	7.9	26.4
Max	**21.6**	**3.2**	**195.2**	**17.4**	**8.5**	**34.4**
Patty's Rock						
Surface						
April 29 - December 7						
Min	10.2	0.6	59.7	5.6	7.3	0.1
Mean	17.1	0.9	80.1	7.4	8.1	12.7
Max	**23.2**	**1.4**	**142.2**	**12.8**	**8.8**	**32.6**
Mid-Depth						
April 29 - December 7						
Min	9.6	2.2	0.0	0.0	7.2	0.1
Mean	13.9	3.1	93.2	8.1	7.8	28.1
Max	**23.5**	**3.5**	**187.7**	**16.8**	**8.5**	**33.8**
Bridgehaven						
Surface						
May 29 - December 7						
Min	8.4	0.8	24.1	2.0	7.5	0.1
Mean	16.7	0.9	109.9	9.9	8.2	13.7
Max	**23.5**	**1.1**	**420.4**	**35.4**	**8.9**	**32.7**
Mid-Depth						
June 3 - December 7						
Min	10.5	2.4	4.9	0.4	7.2	3.2
Mean	14.4	3.0	90.1	7.7	7.9	28.1
Max	**23.6**	**3.6**	**153.0**	**13.2**	**8.7**	**32.2**
Sheephouse Creek						
Surface						
April 29 - December 7						
Min	8.5	0.7	55.0	4.9	7.2	0.1
Mean	18.0	1.0	97.3	8.9	8.0	5.9
Max	**24.1**	**1.6**	**204.2**	**18.7**	**9.3**	**29.5**
Mid-Depth						
April 29 - December 7						
Min	9.8	2.8	6.0	0.5	7.3	0.1
Mean	16.4	3.2	98.2	8.3	7.9	24.3
Max	**23.9**	**4.1**	**192.1**	**16.8**	**8.5**	**31.4**
Heron Rookery						
Mid-Depth						
April 22 - December 7						
Min	8.8	3.0	0.4	0.0	6.7	0.1
Mean	18.8	3.2	79.3	7.1	7.8	8.8
Max	**24.7**	**5.9**	**135.2**	**11.8**	**8.7**	**29.1**
Bottom						
April 22 - December 7						
Min	9.8	4.7	6.6	0.5	7.0	0.1
Mean	18.2	5.8	66.6	5.7	7.8	13.3
Max	**23.5**	**7.7**	**140.1**	**11.4**	**8.7**	**29.5**
Freezeout Creek						
Mid-Depth						
April 22 - December 4						
Min	10.0	3.1	1.7	0.1	6.8	0.1
Mean	19.5	3.9	79.9	7.2	7.9	4.9
Max	**24.8**	**5.3**	**141.1**	**12.2**	**8.8**	**24.5**
Bottom						
April 22 - December 7						
Min	12.2	4.7	0.5	0.0	6.0	0.1
Mean	18.8	6.4	70.7	6.3	7.2	10.1
Max	**24.2**	**7.7**	**147.7**	**13.6**	**8.7**	**24.5**

The following sections provide a brief discussion of the results observed for each parameter monitored.

Salinity

Full strength seawater has a salinity of approximately 35 ppt, with salinity decreasing from the ocean to the upstream limit of the Estuary, which is considered freshwater at approximately 0.5 ppt (Horne 1994). All of the mid-depth sondes in the lower and middle reaches were located in a predominantly saline environment, whereas the surface sondes were located at the saltwater-freshwater interface (halocline or salt wedge) and recorded both freshwater and saltwater conditions. In the middle reach of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface.

In the upper reach, the Estuary begins to transition to a predominantly brackish and freshwater environment in the Heron Rookery area. The Freezeout Creek station is located in a predominantly freshwater environment; however, saltwater does occur in the lower half of the water column during open estuary conditions with lower in-stream flows, as well as during barrier beach closure.

Lower and Middle Reach Salinity

The surface sondes at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek stations were suspended at a depth of approximately 1 meter, and experienced frequent hourly fluctuations in salinity. These fluctuations are caused by tidal movement and expansion and contraction of the salt wedge. The surface sondes at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek had mean salinity values of 15.0, 12.7, 13.7, and 5.9 ppt, respectively (Table 4.1.1). However, concentrations ranged from 0.2 to 33.7 ppt at the Mouth surface sonde, 0.1 to 32.6 ppt at the Patty's Rock Surface Station, 0.1 to 32.7 ppt at the Bridgehaven Surface Sonde, and 0.1 to 29.5 ppt at the Sheephouse Creek surface sonde.

Salinity concentrations were observed to decrease at the surface sondes in response to barrier beach closure (Figures 4.1.3 through 4.1.6). This is due to a combination of freshwater inflows increasing the depth of the freshwater layer over the salt layer, the resulting compression of the salt layer, and seepage of saline water through the barrier beach. Salinity returned to pre-closure levels after the mouth was breached, although the time required to return to pre-breach conditions varied at each site and differed between closure events. This variability was related to the strength of subsequent tidal cycles, freshwater inflow rates, topography, relative location within the Estuary, and to a lesser degree, wind mixing.

The mid-depth sondes at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek had mean salinity values of 26.4, 28.1, 28.1, and 24.3 ppt, respectively (Table 4.1.1). Additionally, concentrations ranged from 0.2 to 34.4 ppt at the Mouth mid-depth sonde, 0.1 to 33.8 ppt at the Patty's Rock mid-depth Station, 3.2 to 32.2 ppt at the Bridgehaven mid-depth sonde, and 0.1 to 31.4 ppt at the Sheephouse Creek mid-depth sonde. The minimum values were not

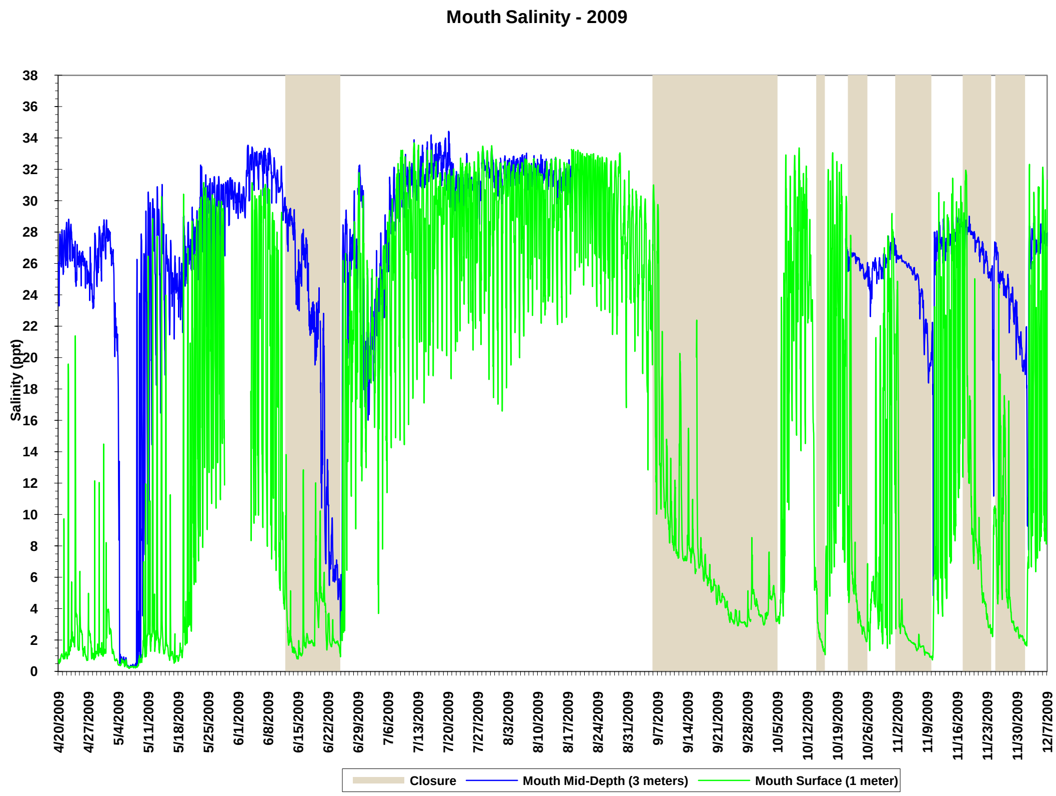


Figure 4.1.3. 2009 Russian River Mouth Salinity Graph

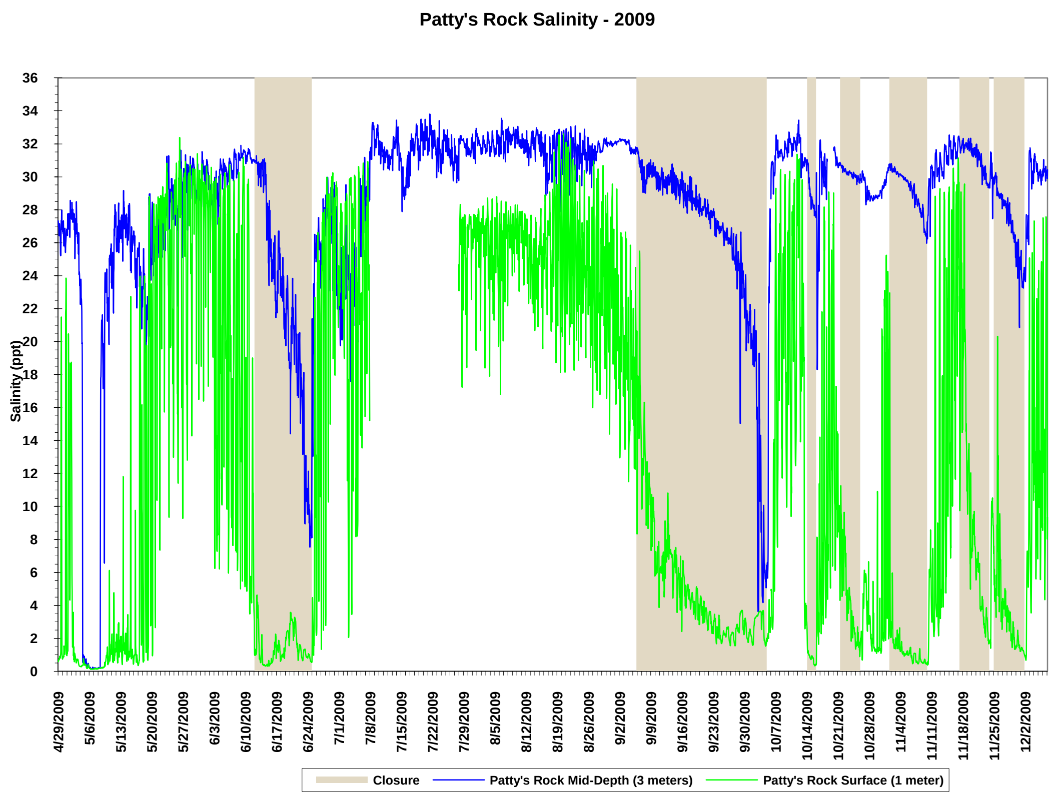


Figure 4.1.4. 2009 Russian River at Patty's Rock Salinity Graph

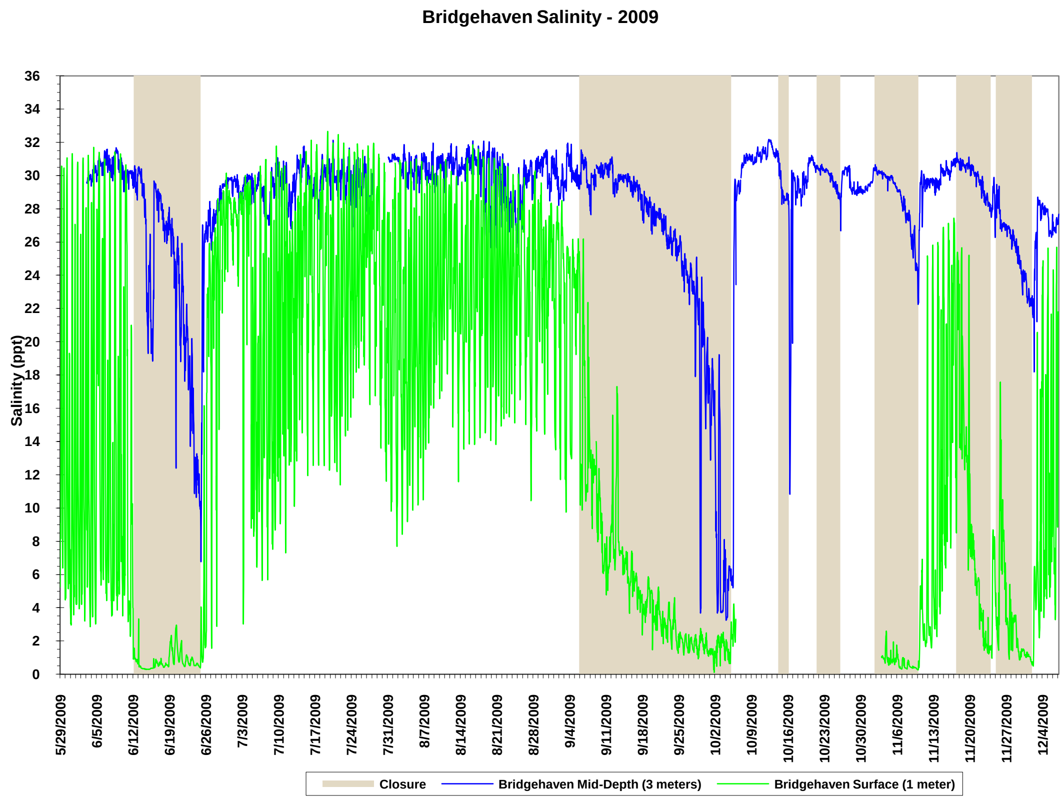


Figure 4.1.5. 2009 Russian River at Bridgehaven Salinity Graph

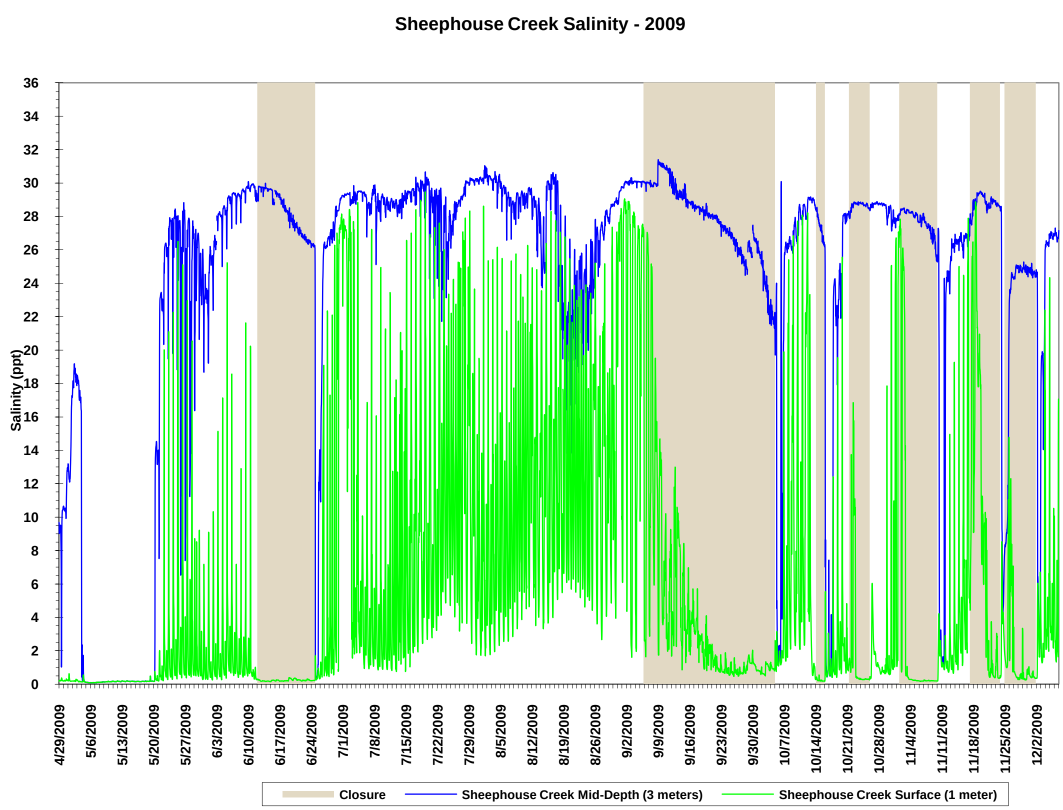


Figure 4.1.6. 2009 Russian River at Sheephouse Creek Salinity Graph

associated with hourly fluctuations like those observed at the surface sondes. Instead, they were a result of freshwater flows that temporarily displaced the saltwater at these stations from late-spring storm events in May, thickening of the freshwater layer during barrier beach closure, and flushing events (observed at Sheephouse Creek) following the breaching of the barrier beach (Figures 4.1.3 through 4.1.6).

Upper Reach Salinity

Two stations were monitored in the upper reach in 2009; Heron Rookery and Freezeout Creek. Both stations included a bottom sonde and a mid-depth sonde. Sondes were located in this manner to track changes in concentration of salinity in the water column. The Heron Rookery station is located approximately 7.5 km upstream from the mouth of the river in a deep pool. This station is situated about half way between the Sheephouse Creek station and the Freezeout Creek station, where the Estuary begins to transition from predominantly saline conditions to brackish and freshwater conditions. The Bottom and mid-depth sondes at Heron Rookery had mean salinity concentrations of 13.3 ppt and 8.8 ppt, respectively (Table 4.1.1). The bottom sonde was observed to have salinity levels that ranged from 0.1 to 29.5 ppt, which was nearly identical to the 0.1 to 29.1 ppt range of salinity observed at the mid-depth sonde.

The Freezeout Creek station is located approximately 9.5 km upstream from the river mouth in a pool approximately 300 meters downstream of the confluence of Freezeout Creek and the mainstem of the river. This station was located in a predominantly freshwater habitat that was occasionally subject to elevated salinity levels as the salt wedge migrated up the Estuary during both open and closed conditions. The bottom and mid-depth sondes at Freezeout Creek had mean salinity concentrations of 10.1 and 4.9 ppt, respectively. Correspondingly, the bottom and mid-depth sondes had salinity levels that ranged from 0.1 to 24.5 ppt.

The salt wedge migrated to the Heron Rookery and Freezeout Creek stations during open conditions from early July to early October when freshwater inflows decreased below 150 cfs (Figures 4.1.7 and 4.1.8). However, concentrations varied during open conditions due to tidal cycles and changes in freshwater inflow. Additionally, saline conditions increased and persisted at the mid-depth and bottom sondes following barrier beach closure. This upstream movement of the salt wedge during barrier beach closure, as observed by an increase in salinity concentrations, suggests that the salt layer is stratifying and flattening out underneath the developing freshwater layer. A reduction in freshwater inflow over the season facilitated the upstream migration of the salt wedge into the Freezeout Creek area.

During the 29-day closure event, salinity levels increased in the Estuary (as observed at the Heron Rookery station) following two large wave over splash events associated with high ocean swells in early September (Figure 4.1.7). Wave over splash occurs when ocean swells push waves over the barrier beach transporting full strength seawater into the closed Estuary. Following the initial increases associated with these events, salinity levels began to decrease at the Mid-depth Sondes, but salinity persisted at the bottom sondes during the entire closure event.

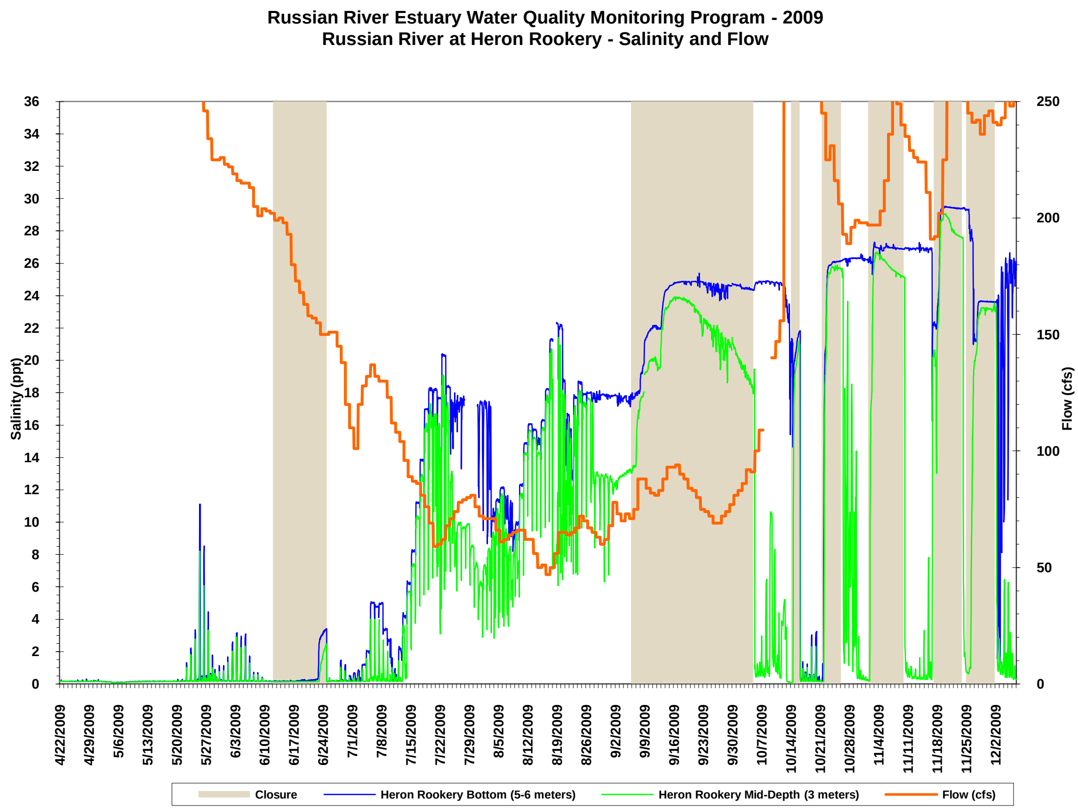


Figure 4.1.7. 2009 Russian River at Heron Rookery Salinity and Flow Graph

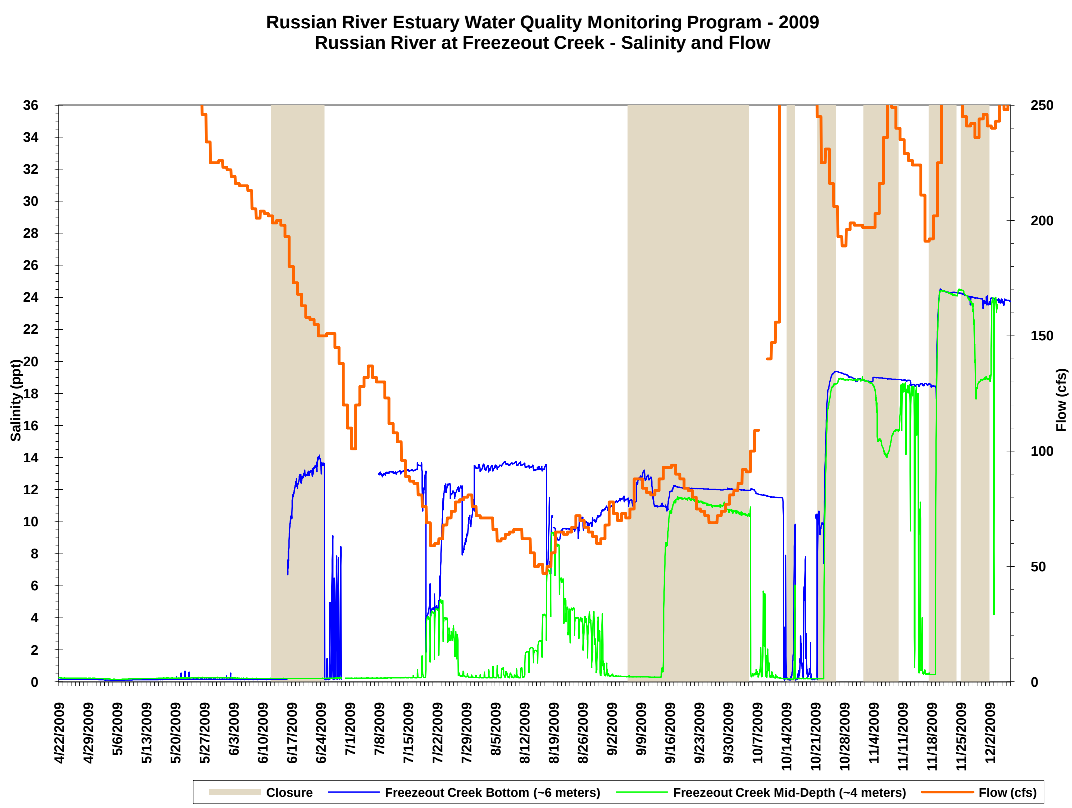


Figure 4.1.8. 2009 Russian River at Freezeout Creek Salinity and Flow Graph

Following breaching of the barrier beach, salinity levels decreased at the mid-depth sondes as the salt wedge began migrating back downstream during subsequent tidal cycles. However, salinity levels remained relatively unchanged at the bottom sondes of Heron Rookery and Freezeout Creek for several days following the October 5, breaching of the river mouth, until elevated freshwater flows associated with a storm event pushed the salt wedge further downstream (Figures 4.1.7 and 4.1.8).

Subsequently, during a series of short-term closures that occurred from late October to early December, salinity concentrations were observed to consecutively increase and become persistent with salinity levels as high as 30 ppt at the bottom of the Heron Rookery station and 25 ppt at the bottom of the Freezeout Creek station by mid-November.

Temperature

During open estuary conditions, water temperatures were reflective of the halocline, with lower mean and maximum temperatures typically being observed in the saline layer at the bottom and mid-depth sondes compared to temperatures recorded in the freshwater layer at the mid-depth and surface sondes (Figures 4.1.9 through 4.1.14). The differences in maximum temperatures between the underlying saline layer and the overlying freshwater layer can be attributed in part to the source of saline and fresh water. During open estuary conditions, the Pacific Ocean, where temperatures are typically around 10 degrees C, is the source of saltwater in the Estuary. Whereas, the mainstem Russian River, with temperatures reaching as high as 25 degrees C in the interior valleys, is the primary source of freshwater in the Estuary.

However, during barrier beach closure, including the extended 29-day closure, fresh/saltwater stratification was observed to occur. Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent/minimize mixing of the freshwater and saline layers. Over time, solar radiation heats the mid-depth saline layer, and the overlying surface freshwater layer restricts the release of heat. This often resulted in higher water temperatures in the mid-depth saline layer than in the overlying surface freshwater layer and underlying bottom saline layer located below the effects of solar heating (Figures 4.1.9 through 4.1.14). This stratification based heating also contributed to higher seasonal mean and maximum temperatures in the mid-depth saline layer than would be expected to occur under open conditions. The lowest recorded temperatures overall were associated with freshwater inflow at the end of the season in December. During this time of the year, freshwater is often colder than ocean water.

Lower and Middle Reach Temperature

The mid-depth sondes were located primarily in saltwater and had maximum temperatures of 21.6, 23.5, 23.6, and 23.9 degrees C at the Mouth, Patty’s Rock, Bridgehaven and Sheephouse Creek, respectively (Table 4.1.1). The lower seasonal maximum temperature at Mouth mid-depth sonde resulted from an equipment malfunction during the extended closure at a time when the other mid-depth stations were recording the highest temperatures of the season in the stratified saline layer (Figure 4.1.9).

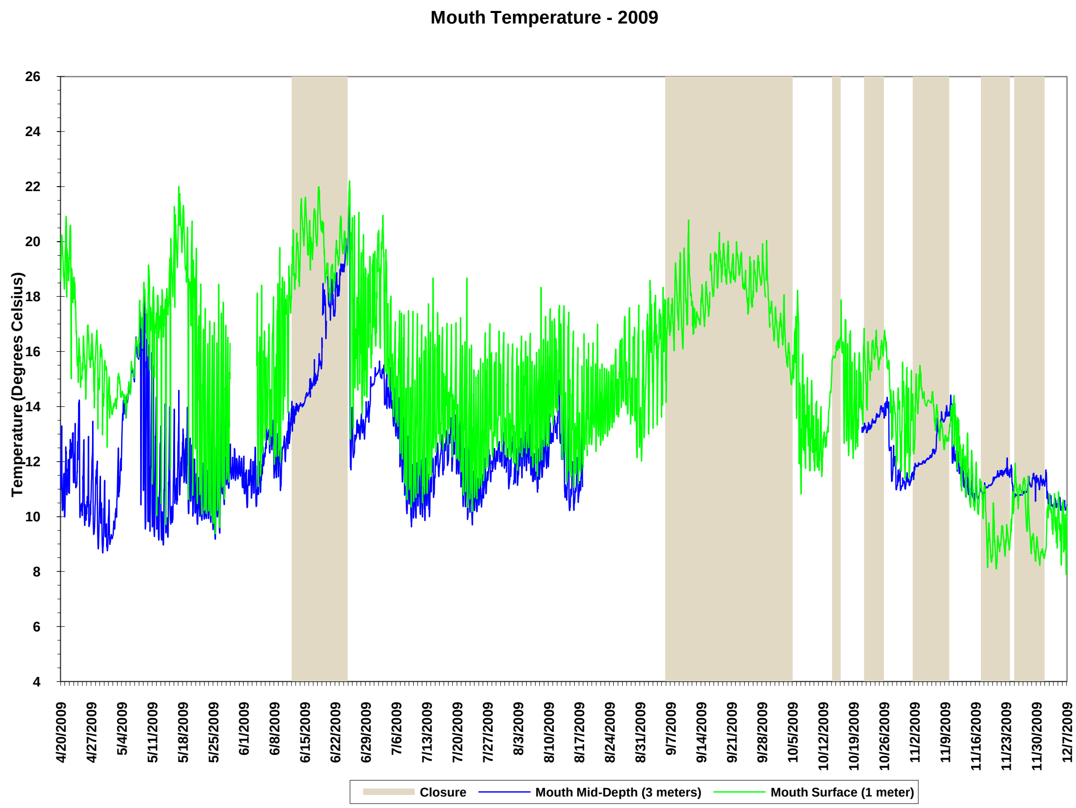


Figure 4.1.9. 2009 Russian River Mouth Temperature Graph

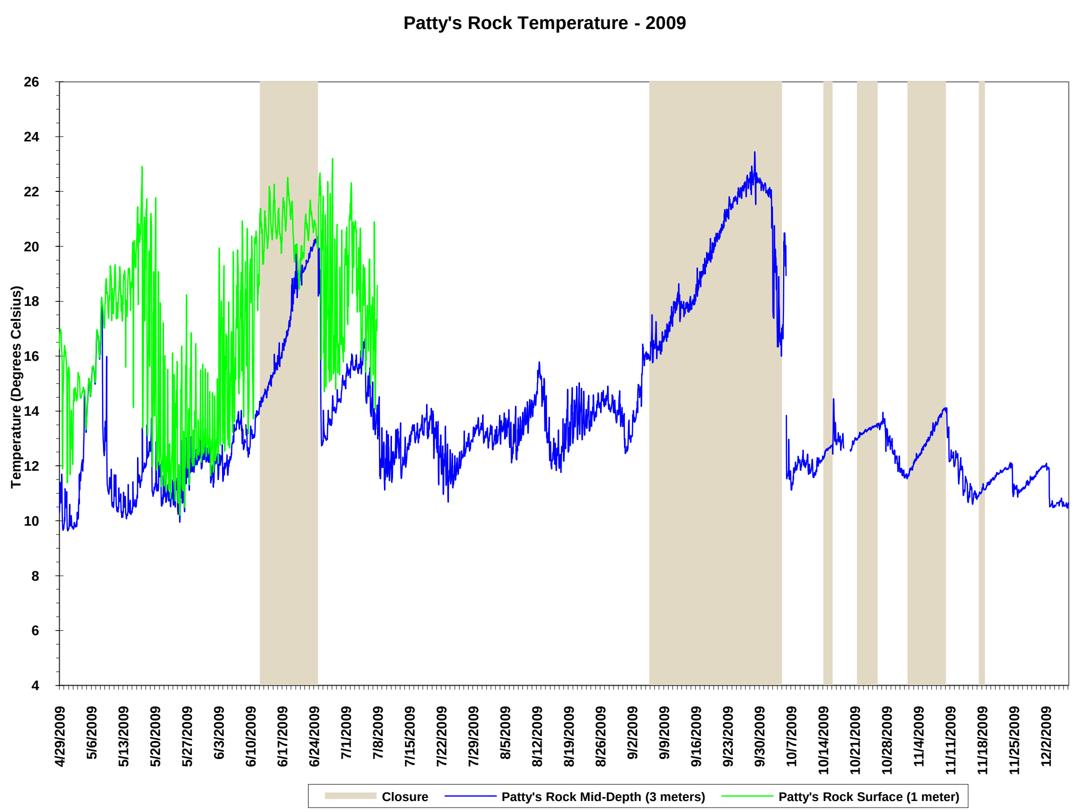


Figure 4.1.10. Russian River at Patty's Rock Temperature Graph

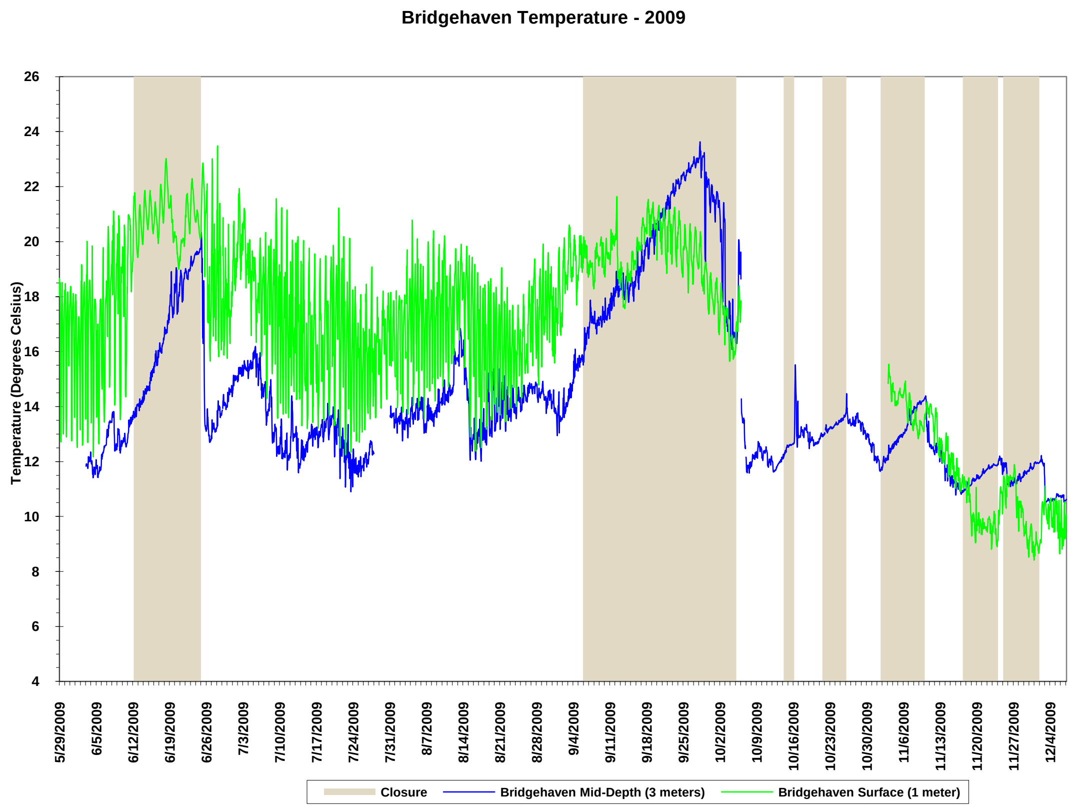


Figure 4.1.11. 2009 Russian River at Bridgehaven Temperature Graph

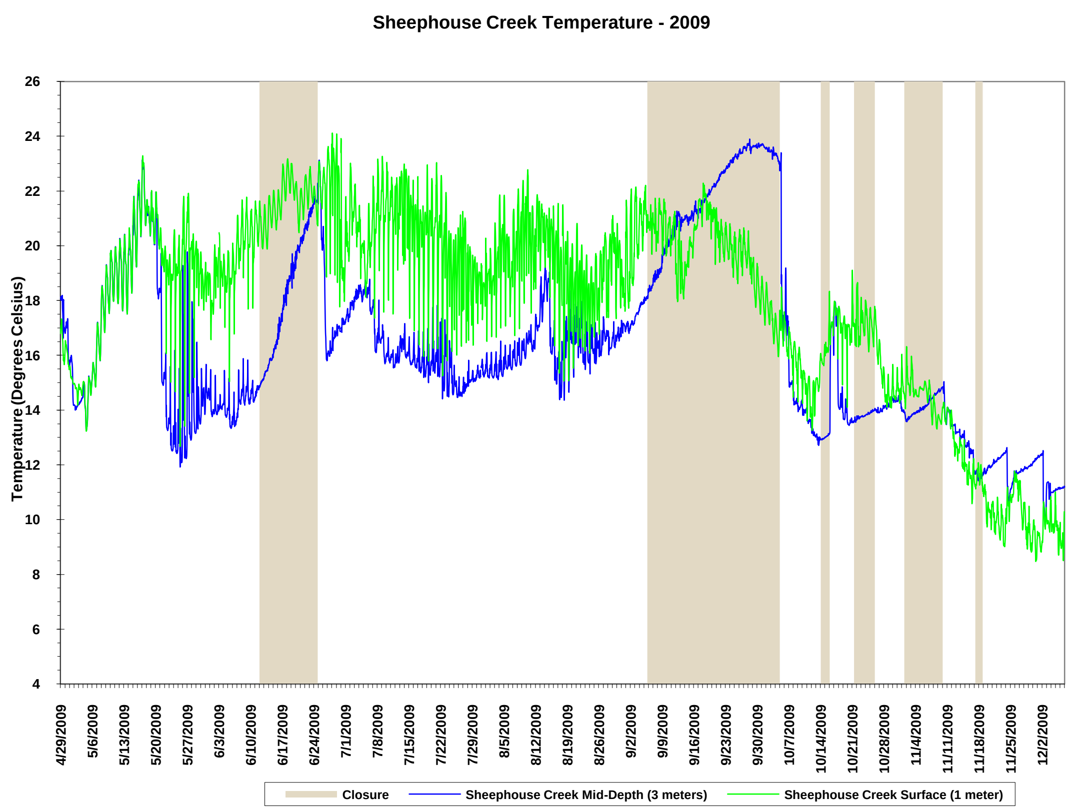


Figure 4.1.12. 2009 Russian River at Sheephouse Creek Temperature Graph

The surface sondes were located at the freshwater/saltwater interface and were observed to have maximum temperatures of 22.2, 23.2, 23.5, and 24.1 degrees C at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek, respectively. The Sheephouse Creek surface sonde had a higher maximum temperature of 24.1 degrees C when compared to the maximum of 22.2 degrees C recorded at the Mouth surface sonde (Table 4.1.1). This is partially due to the Sheephouse Creek station being the furthest upstream of the lower and middle reach stations, where the freshwater layer has the least amount of cooling time as the river leaves the warmer canyons around Guerneville and Monte Rio and enters the cooler climate near the coastline. The Sheephouse Creek station is approximately 5.1 km (3.2 mi) upstream from the Mouth Station, 2.7 km (1.7 mi) inland from the coastline, and behind two ridgelines to the west and south that provide additional protection from the influences of marine fog and wind.

The mid-depth sondes had mean temperatures of 12.3, 13.9, 14.4, and 16.4 degrees C at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek, respectively (Table 4.1.1). The surface sondes had mean temperatures of 15.0, 17.1, 16.7, and 18.0 degrees C at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek, respectively (Table 4.1.1). The high mean temperature at the Patty's Rock surface sonde, relative to the Mouth and Bridgehaven mean temperatures, can be partially attributed to a data gap associated with equipment malfunction that occurred from July until the end of the monitoring season in December (Figure 4.1.10).

The mid-depth sondes had minimum temperatures of 8.7, 9.6, 10.5, and 9.8 degrees C at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek, respectively (Table 4.1.1). The surface sondes had minimum temperatures of 7.9, 10.2, 8.4, and 8.5 degrees C at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek, respectively (Table 4.1.1). Again, differences between stations can be partially attributed to data gaps associated with equipment malfunctions, as well as different monitoring periods.

Upper Reach Temperature

Overall temperatures in both the saline layer and freshwater layer were typically hottest at the furthest upstream stations, as recorded at Heron Rookery and Freezeout Creek, and became progressively cooler as the water flows downstream, closer to the cooling effects of the coast and ocean. For example, during open conditions on 17 May, a maximum freshwater temperature of 23.9 degrees C was observed at the Heron Rookery station (Figure 4.1.13); whereas the maximum freshwater temperature observed at the Mouth station was 22.0 degrees C (Figure 4.1.9).

The bottom sondes at Heron Rookery and Freezeout Creek had maximum temperatures of 23.5 and 24.2 degrees C, mean temperatures of 18.2 and 18.8 degrees C, and minimum temperatures of 9.8 and 12.2 degrees C, respectively (Table 4.1.1). The mid-depth sondes at Heron Rookery and Freezeout Creek had maximum temperatures of 24.7 and 24.8 degrees C, mean temperatures of 18.8 and 19.5 degrees C, and minimum temperatures of 8.8 and 10.0 degrees C, respectively (Table 4.1.1).

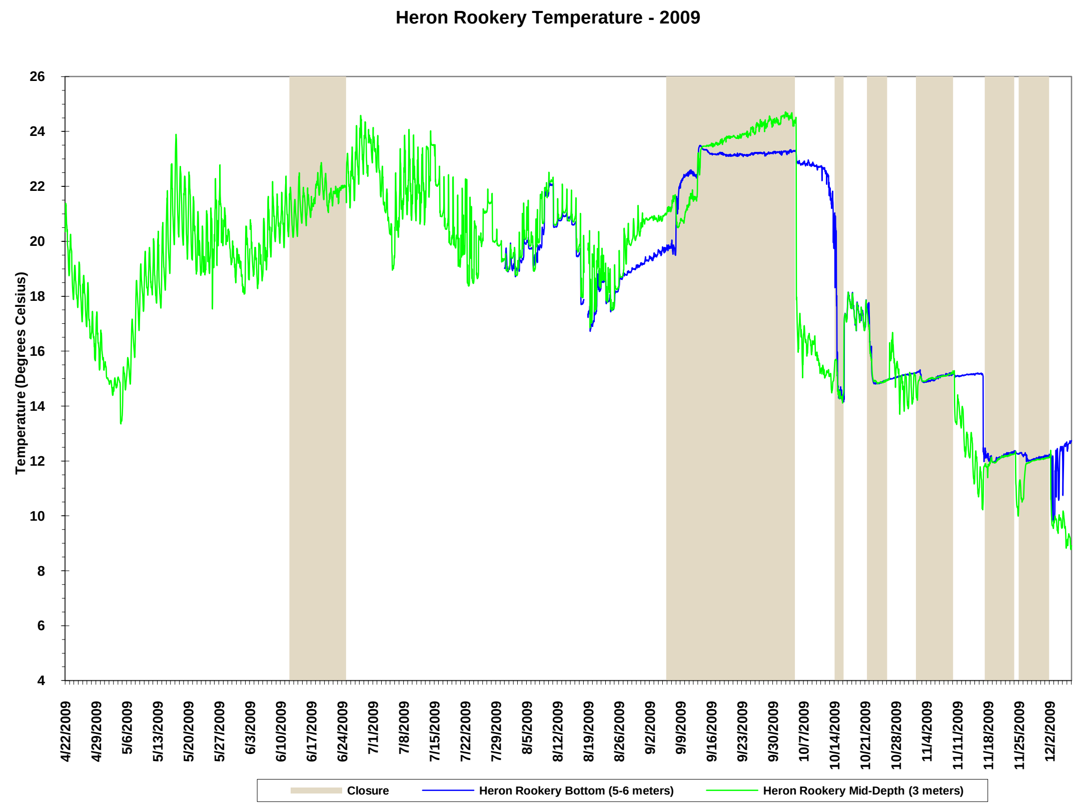


Figure 4.1.13. 2009 Russian River at Heron Rookery Temperature Graph

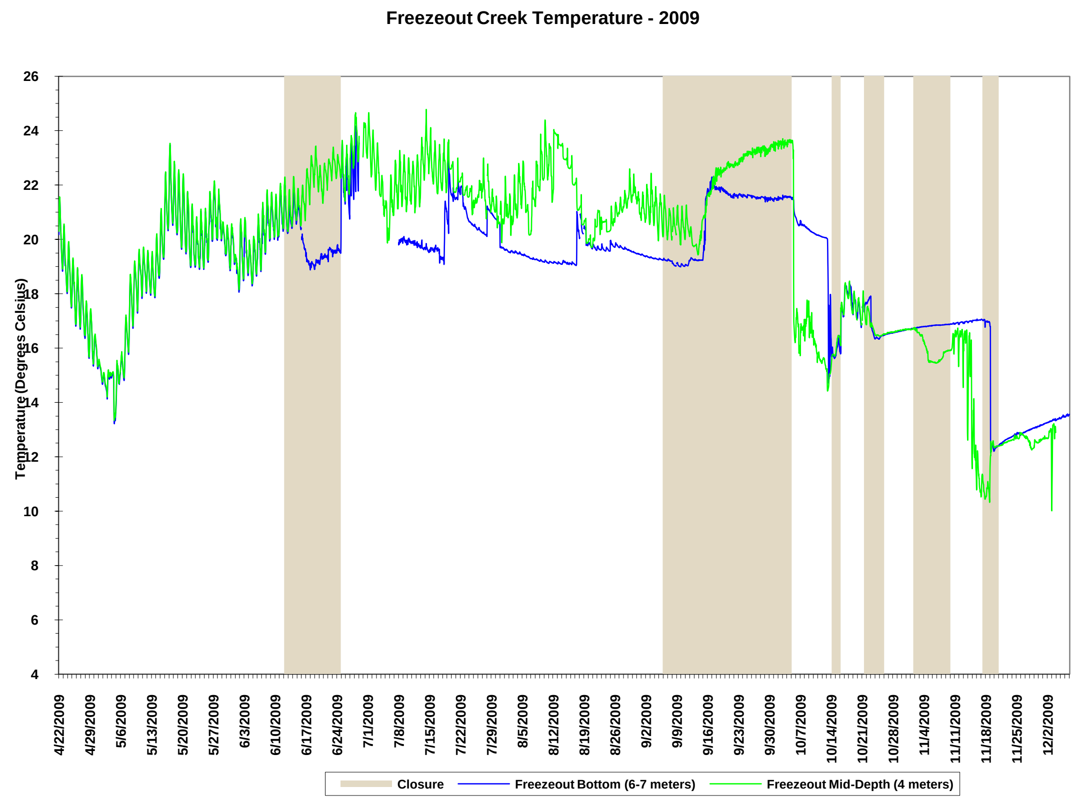


Figure 4.1.14. 2009 Russian River at Freezeout Creek Temperature Graph

During open estuary conditions in the Lagoon Management Period, water temperatures in the upper reach of the Estuary were observed to be cooler in the saline layer than the overlying freshwater layer (Figures 4.1.13 and 4.1.14). However, during closed barrier beach conditions, stratification related heating of the saline layer was observed in the upper reach similar to that observed in the lower and middle reaches (Figures 4.1.10 through 4.1.12). Temperatures in the saline layer typically decreased following breaching of the barrier beach, and can be attributed to downstream migration of the salt wedge and replacement by cooler freshwater and/or mixing with cooler ocean water during subsequent tidal cycles.

Dissolved Oxygen

Dissolved oxygen (DO) levels in the Estuary depend upon factors such as the extent of diffusion from surrounding air and water movement, including freshwater inflow. DO is affected by salinity and temperature stratification, tidal and wind mixing, abundance of aquatic plants, and presence of decomposing organic matter. DO affects fish growth rates, embryonic development, metabolic activity, and under severe conditions, stress and mortality. Cold water has a higher saturation point than warmer water; therefore cold water is capable of carrying higher levels of oxygen.

DO levels are also a function of nutrients, which can accumulate in water and promote plant and algal growth that both consume and produce DO during respiration and photosynthesis. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff *enters* the marine environment in a confined channel[5]. Upwelling in coastal systems also promotes increased productivity by conveying deep, nutrient-rich waters to the surface, where the nutrients can be assimilated by algae. Excessive nutrient concentrations and plant and algal growth can overwhelm eutrophic systems and lead to a reduction in DO levels that can affect the overall ecological health of the Estuary.

Dissolved oxygen concentrations in the lower and middle reaches were generally higher at the surface sondes compared to the mid-depth sondes at a given sampling station (Figures 4.1.15 through 4.1.18). The surface sondes typically had the highest mean DO concentrations, as well as the highest maximum and minimum concentrations, when compared with the mid-depth sondes (Table 4.1.1). Supersaturation conditions observed at all the surface sondes contributed to the higher maximum and mean DO concentrations, with the most significant events occurring at the Mouth and Bridgehaven stations (Figures 4.1.15 and 4.1.17). Supersaturation events were also observed at the mid-depth sondes. They were typically less significant and occurred less frequently than events at the corresponding surface sondes; however, the Patty's Rock mid-depth sonde did experience superstation conditions that exceeded DO concentrations at the surface sonde during the month of May (Figure 4.1.16).

Dissolved oxygen concentrations in the upper reach were fairly consistent among stations. However, they were typically lower than DO concentrations observed in the lower and middle

[5] *National Estuarine Eutrophication Assessment* by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

reaches, which can partially be attributed to recurring hypoxic and anoxic conditions in the saline layer during both open and closed Estuary conditions, most significantly at the Freezeout Creek station.

Lower and Middle Reach DO

Mean DO concentrations at the mid-depth sondes were fairly consistent from station to station, with mean DO concentrations of 7.4, 8.1, 7.7, and 8.3 mg/L at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek stations, respectively (Table 4.1.1). The Surface Sondes also had fairly consistent mean DO concentrations of 10.8, 7.4, 9.9, and 8.9 mg/L at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek, respectively (Table 4.1.1). However, the relatively low mean dissolved oxygen concentration at the Patty's Rock surface sonde can be partially attributed to a data gap associated with equipment malfunction that occurred from June until the end of the monitoring season in December, when several supersaturation events were observed to occur at the Mouth and Bridgehaven surface stations (Figures 4.1.15 and 4.1.17).

Significant fluctuations in DO concentrations were observed at all stations in the lower and middle reaches. Several short-term hypoxic and/or anoxic events were recorded at some of the mid-depth sondes during open Estuary conditions in the Lagoon Management Period; however more pronounced events were observed to occur during periods of barrier beach closure. Short-term hypoxic and anoxic events were not always connected to a specific tidal cycle and typically lasted on the order of a few to several hours.

Frequent hypoxic and/or anoxic events at the mid-depth sondes during barrier beach closure contributed to the lower seasonal mean for those sondes. The data indicated a downward trend in DO concentrations, including periods of prolonged hypoxia and/or anoxia, for the duration of barrier beach closure. Minimum DO concentrations were observed to be 0.4, 0.0, 0.4, and 0.5 mg/L at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek mid-depth sondes, respectively. The lowest DO concentrations observed at the mid-depth sondes occurred immediately following the breaching of the barrier beach after the 29-day closure (Figures 4.1.16 through 4.1.18), with the exception of the Mouth mid-depth sonde, which experienced an equipment malfunction at that time (Figure 4.1.15). Recovery of DO concentrations following reopening of the barrier beach was variable in timing and relative concentration among stations and sondes, but typically occurred within a day of the barrier beach being opened.

Consequently, all sondes at all depths did experience some degree of fluctuating DO concentrations, especially during periods of barrier beach closure. However, DO concentrations at the surface sondes did not appear to be negatively impacted by barrier beach closure and were observed to either remain similar to pre-closure conditions or increase in some instances. Although the surface sondes at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek had minimum seasonal DO concentrations of 3.4, 5.6, 2.0 and 4.9 mg/L, these values did not coincide with any of the barrier beach closures (Table 4.1.1). Again, differences between stations can be partially attributed to data gaps associated with equipment malfunctions, as

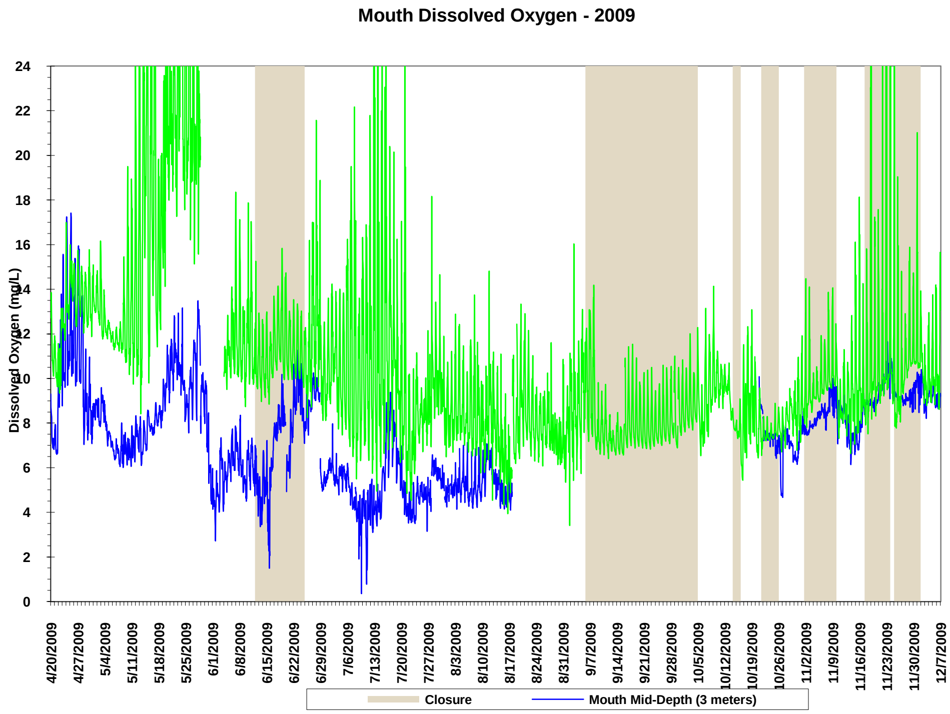


Figure 4.1.15. 2009 Russian River Mouth Dissolved Oxygen Graph

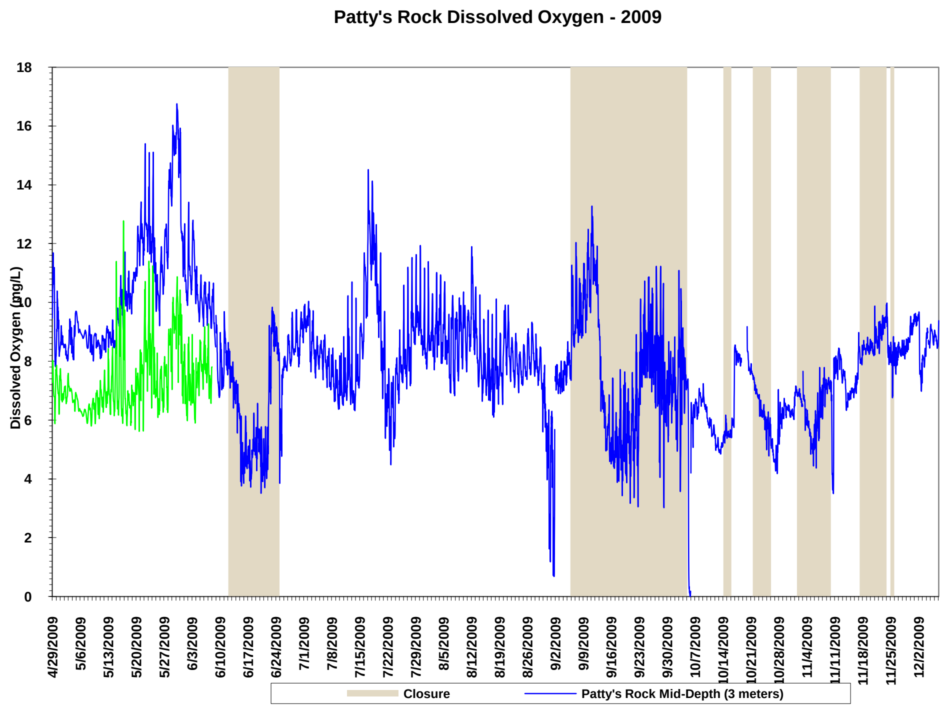


Figure 4.1.16. 2009 Russian River at Patty’s Rock Dissolved Oxygen Graph

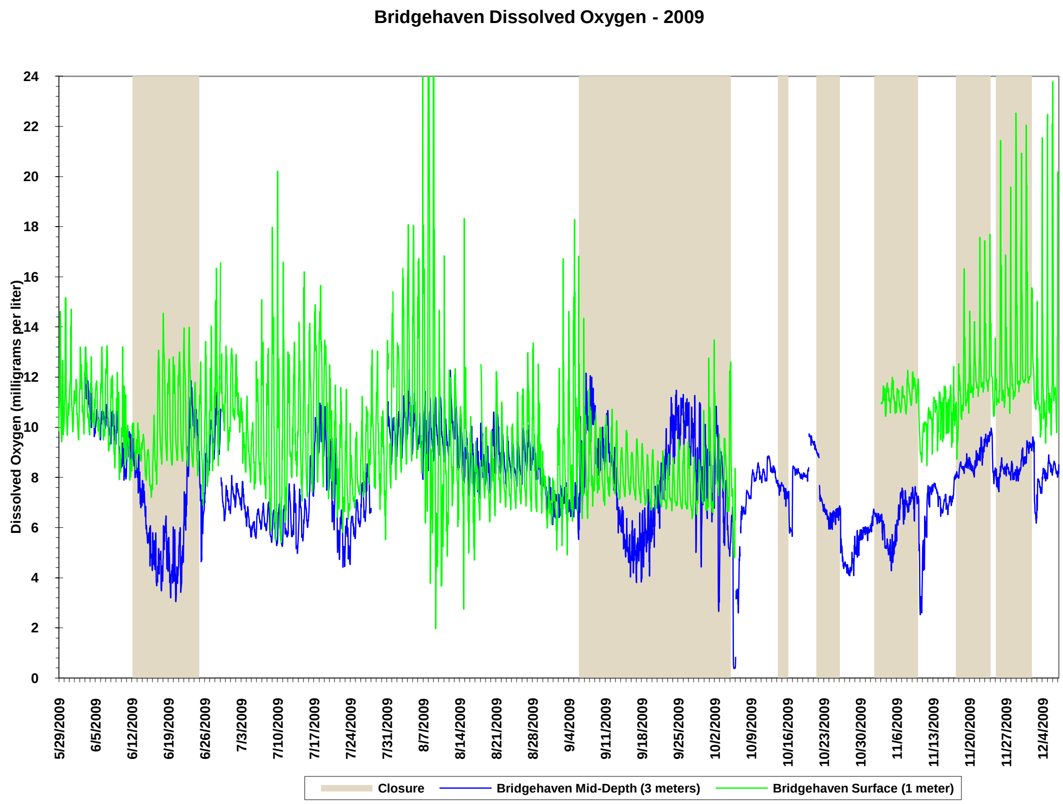


Figure 4.1.17. Russian River at Bridgehaven Dissolved Oxygen Graph

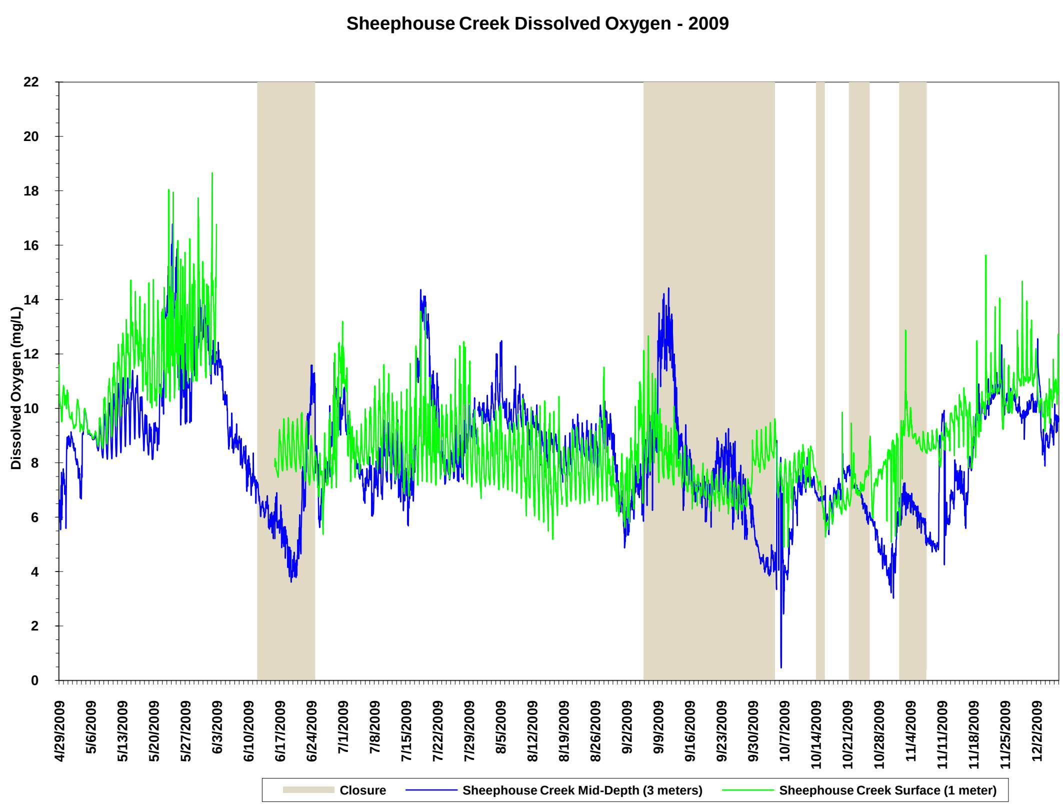


Figure 4.1.18. Russian River at Sheephouse Creek Dissolved Oxygen Graph

well as different monitoring periods. Additional data collection and analysis would be needed to further explore whether any of these conditions represent trends.

The surface sondes, and mid-depth sondes to a lesser degree, also experienced hourly fluctuating supersaturation events. At times when oxygen production exceeds the diffusion of oxygen out of the system, supersaturation may occur (Horne, 1994). DO concentrations exceeding 100% saturation in the water column are considered supersaturated conditions. Because the ability of water to hold oxygen changes with temperature, there are a range of concentration values that correspond to 100% saturation. For instance, at sea level, 100% saturation is equivalent to approximately 11 mg/L at 10 degrees C, but only 8.2 mg/L at 24 degrees C. Consequently, these two temperature values roughly represent the range of temperatures observed in the Estuary during the 2009 monitoring season.

The most significant supersaturation events were observed at the Mouth and Bridgehaven Surface Sondes (Figures 4.1.15 and 4.1.17). Maximum DO concentrations at the Mouth and Bridgehaven Surface Sondes were approximately 46.3 mg/L (500%) and 35.4 mg/L (420%), compared to the Patty's Rock and Sheephouse Creek surface sondes, which had maximum DO concentrations of approximately 12.8 mg/L (142%) and 18.7 mg/L (204%), respectively (Table 4.1.1).

Maximum DO concentrations at the Mid-Depth sondes were approximately 17.4 mg/L (195%) at the Mouth, 16.8 mg/L (188%) at Patty's Rock, 13.2 mg/L (153%) at Bridgehaven, and 16.8 mg/L (192%) at Sheephouse Creek. Again, differences between stations can be partially attributed to data gaps associated with equipment malfunctions, as well as different monitoring periods.

Upper Reach DO

Dissolved oxygen concentrations in the upper reach were slightly lower overall compared to concentrations in the lower and middle reaches (Table 4.1.1). Two factors contributed to these lower values, including more frequent and persistent hypoxic and/or anoxic conditions in the saline layer, and less significant supersaturation events. In addition, the Heron Rookery bottom sonde experienced equipment malfunctions that produced a DO data gap from deployment in April to the end of July, likely affecting minimum, mean, and maximum DO values (Figure 4.1.19).

The bottom sondes at Heron Rookery and Freezeout Creek had mean DO concentrations of 5.7 and 6.3 mg/L, maximum concentrations of 11.4 and 13.6 mg/L, and minimum concentrations of 0.5 and 0.0 mg/L, respectively (Table 4.1.1). The mid-depth sondes at Heron Rookery and Freezeout Creek had mean DO concentrations of 7.1 and 7.2 mg/L, maximum concentrations of 11.8 and 12.2 mg/L, and minimum concentrations of 0.0 and 0.1 mg/L (Table 4.1.1).

As late spring flows dropped below approximately 200 cfs, the salt wedge migrated upstream and displaced the freshwater in the lower portion of the water column at the Heron Rookery and Freezeout Creek bottom stations (Figures 4.1.19 and 4.1.20). The salt wedge became persistent in the deep pools during open conditions from early July to early October, however, salinity concentrations continued to fluctuate at the two stations with changes to freshwater inflow rates, tidal inundation and mixing.

DO levels were occasionally depressed during open conditions at the bottom of the saline layer. Values at the Heron Rookery bottom sonde were not as low as they were at the Freezeout Creek bottom sonde, suggesting a greater degree of water column mixing may occur at depth at the Heron Rookery station. However, the Heron Rookery bottom sonde was not located at the absolute bottom of the pool. This placement may also have affected DO values because some anoxic events occurring at the bottom may not have been captured by a sonde located approximately 2 meters above the bottom. Additional data will need to be collected at the absolute bottom of the Heron Rookery station to gain a fuller understanding of the extent of mixing in this part of the Estuary.

DO levels at the mid-depth sondes remained at acceptable levels for salmonids during open conditions, except later in the season when several barrier beach closures occurred in sequence (Figures 4.1.19 and 4.1.20). DO levels occasionally remained depressed between these frequent events.

DO response to barrier beach closure and reopening was also variable throughout the season and dependent on the length of time of the closure, the timing of subsequent closure events, freshwater inflow rates and subsequent tidal inundation and mixing. During the June closure, DO levels at the bottom sondes became hypoxic to anoxic, while DO levels at the mid-depth sondes remained at acceptable levels (Figures 4.1.19 and 4.1.20). During this closure, the bottom sondes were located in the saltwater layer and the mid-depth sondes were located in the freshwater layer. During the extended 29-day closure occurred in September, the salt wedge had migrated further upstream placing the mid-depth sondes within the salt layer and DO levels decreased and became hypoxic to anoxic over time. Following the 29-day extended closure event, DO concentrations persisted at the bottom of the Freezeout Creek and Heron Rookery stations for several days until the salt layer migrated downstream with increased freshwater flows from a storm event and became subject to tidal mixing.

DO levels were variable through the subsequent closure events in October through November, with hypoxic to anoxic conditions being observed in both closed and open conditions as well as normal DO levels being observed during these conditions. The presence of salinity would typically coincide with the presence of depressed DO levels, but not always, suggesting that variability is dependent on changes in the length of time of the closure, the timing of subsequent closure events, freshwater inflow rates and subsequent tidal inundation and mixing.

It is important to note that highly anoxic conditions observed at the Freezeout Creek bottom sonde included the release of hydrogen sulfide (H_2S) into the water column, whereby equipment was observed with staining and odors consistent with releases of H_2S. According to

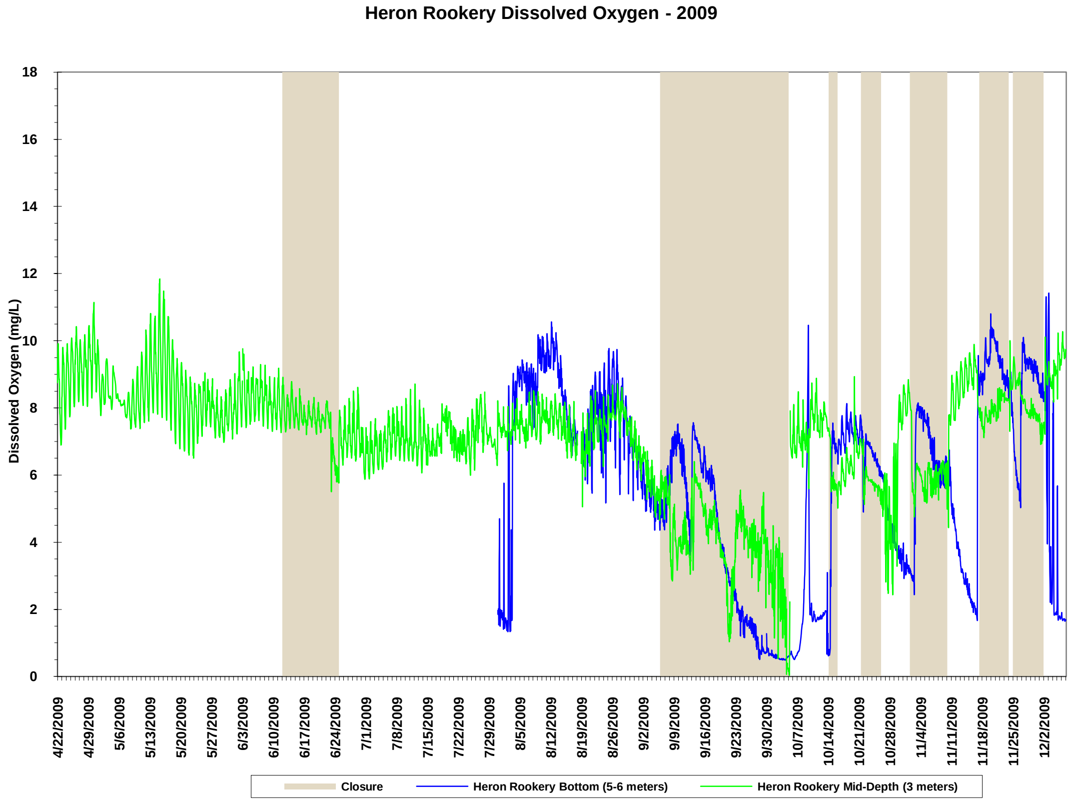


Figure 4.1.19. 2009 Russian River at Heron Rookery Dissolved Oxygen Graph

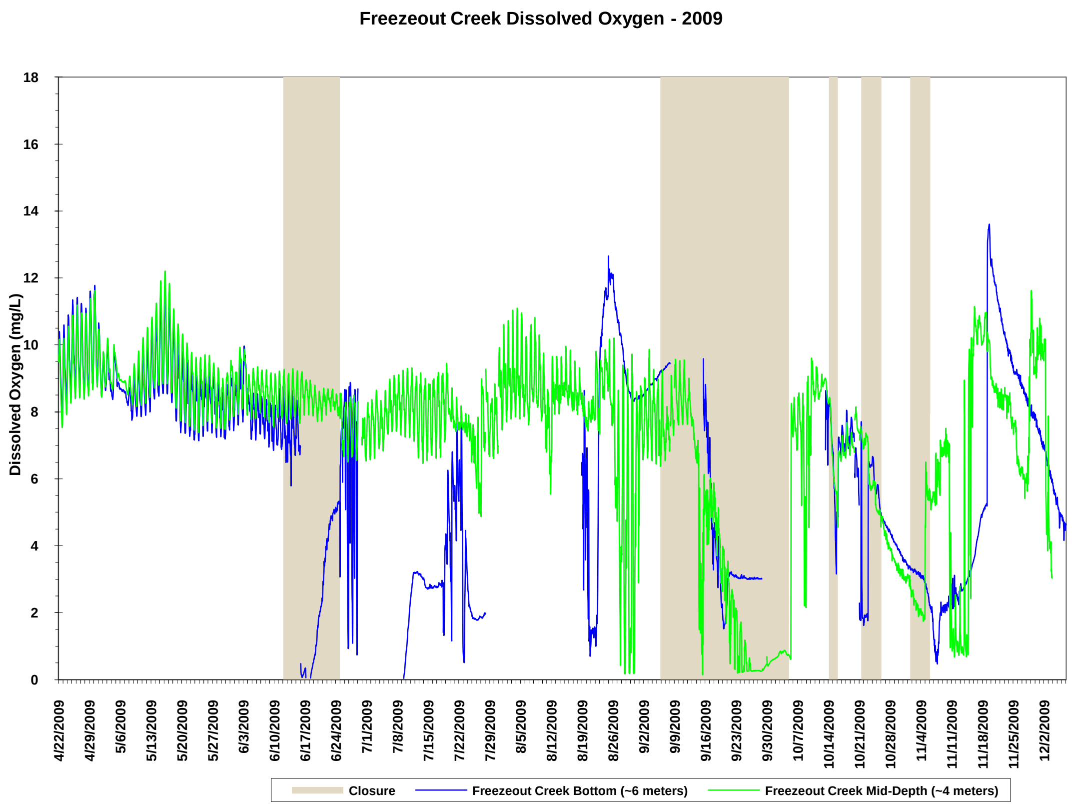


Figure 4.1.20. 2009 Russian River at Freezeout Creek Dissolved Oxygen Graph

the manufacturer, H_2S releases can be read by the YSI datasondes as a false positive for dissolved oxygen. These releases were directly observed by staff during maintenance and calibration efforts and recorded in the data set, where DO levels were observed to spike from anoxic to fully saturated and supersaturated conditions during this time (Figure 4.1.20).

Hydrogen Ion (pH)

Hydrogen ion (pH) values were fairly consistent among all stations at all depths in the lower and middle reaches, with mean values ranging from 7.8 pH at the Patty's Rock Mid-Depth Sonde, to 8.2 pH at the Bridgehaven Surface Sonde. Values were observed to increase slightly at the surface sondes during closed estuary conditions (Figures 4.1.21 through 4.1.24). Whereas pH values were observed to vary at the mid-depth sondes during closures, with decreases and increases appearing to reflect similar decreases and increases of DO concentrations at these stations (see Figures 4.1.18 and 4.1.24 for example). Minimum pH values in the lower and middle reaches ranged from 7.2 pH to 7.5 pH and maximum pH values ranged from 8.5 pH to 9.1 pH (Table 4.1.1).

Minimum, mean, and maximum pH values were slightly lower in the upper reaches at Heron Rookery and Freezeout Creek (Figures 4.1.25 and 4.1.26). Mean pH values ranged from 7.2 to 7.9pH (Table 4.1.1). Minimum pH values were observed to remain above 6.5 pH throughout

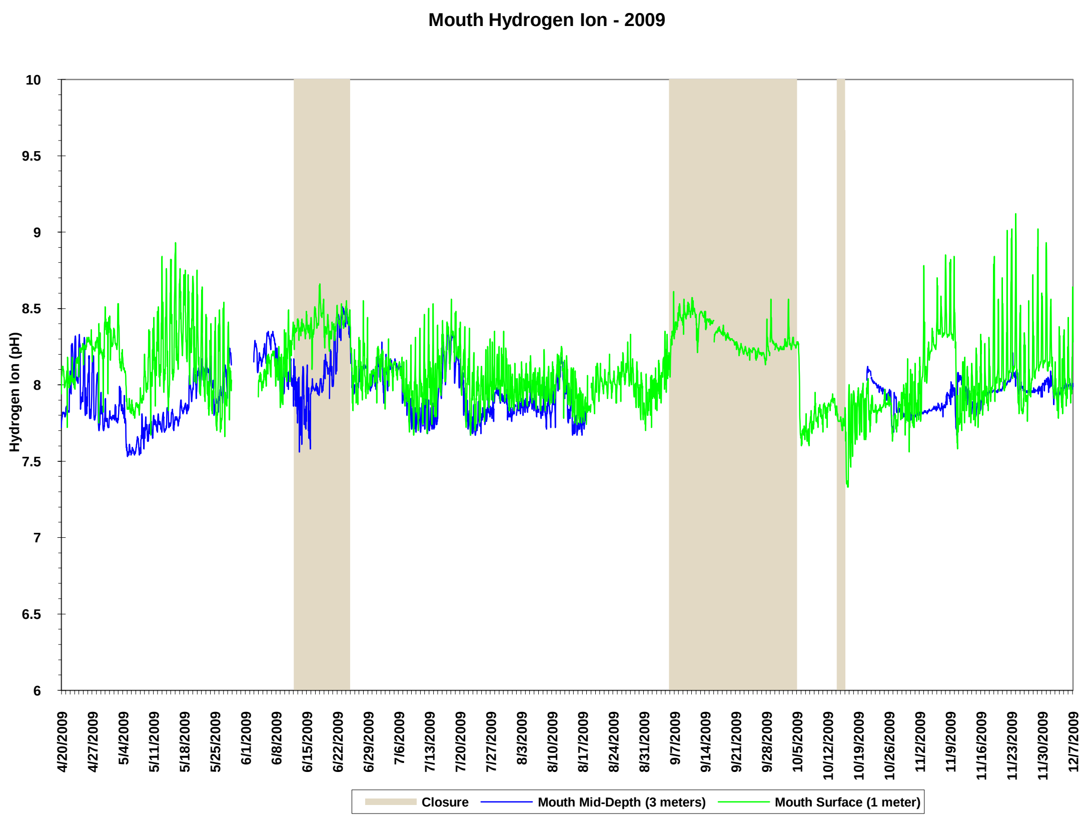


Figure 4.1.21. 2009 Russian River Mouth Hydrogen Ion Graph

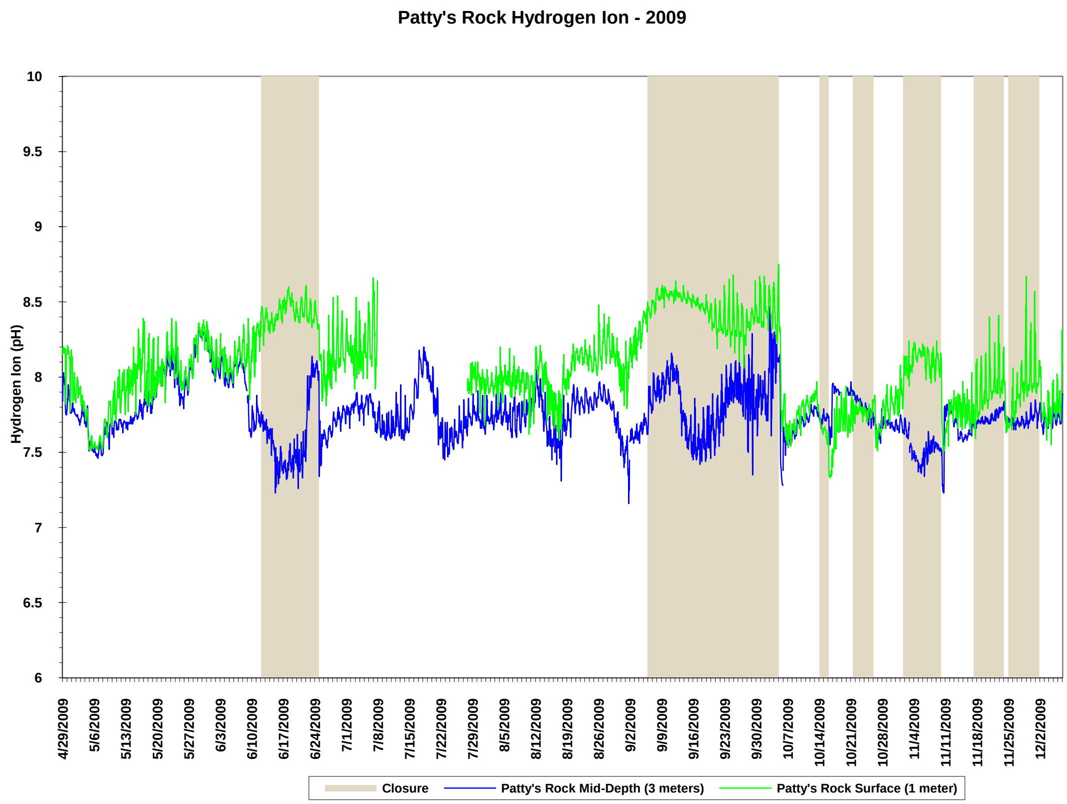


Figure 4.1.22. 2009 Russian River at Patty's Rock Hydrogen Ion Graph

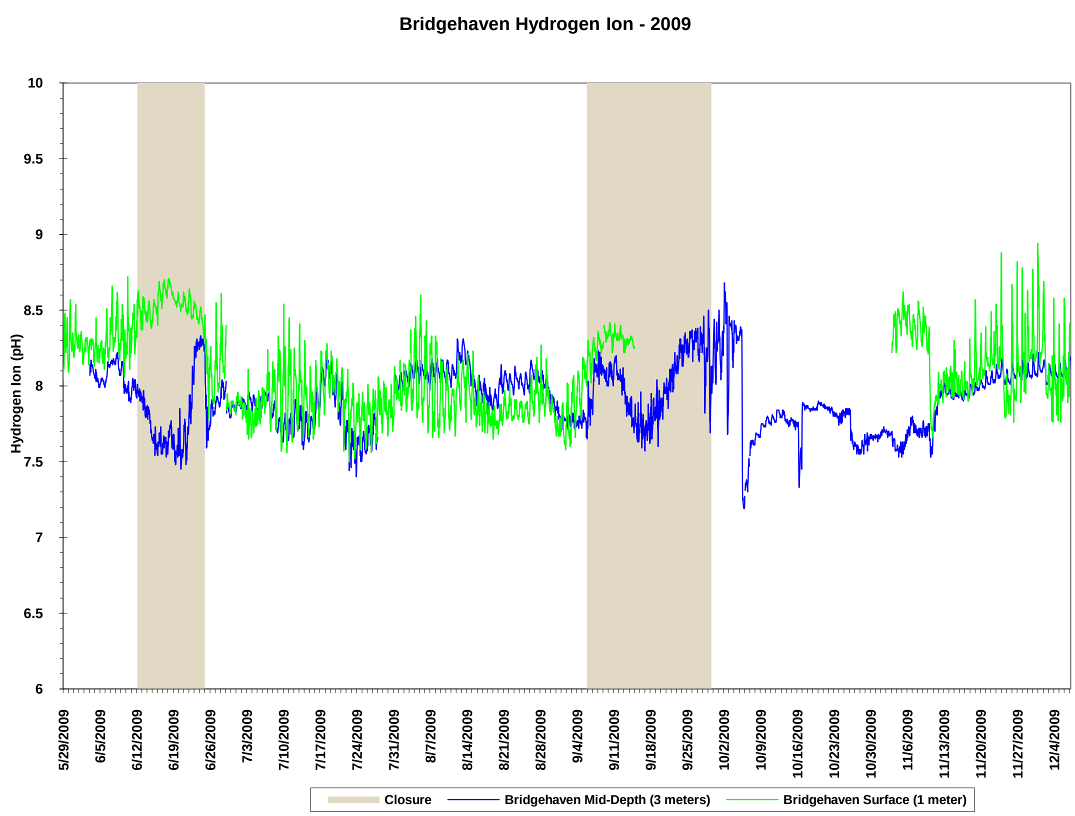


Figure 4.1.23. 2009 Russian River at Bridgehaven Hydrogen Ion Graph

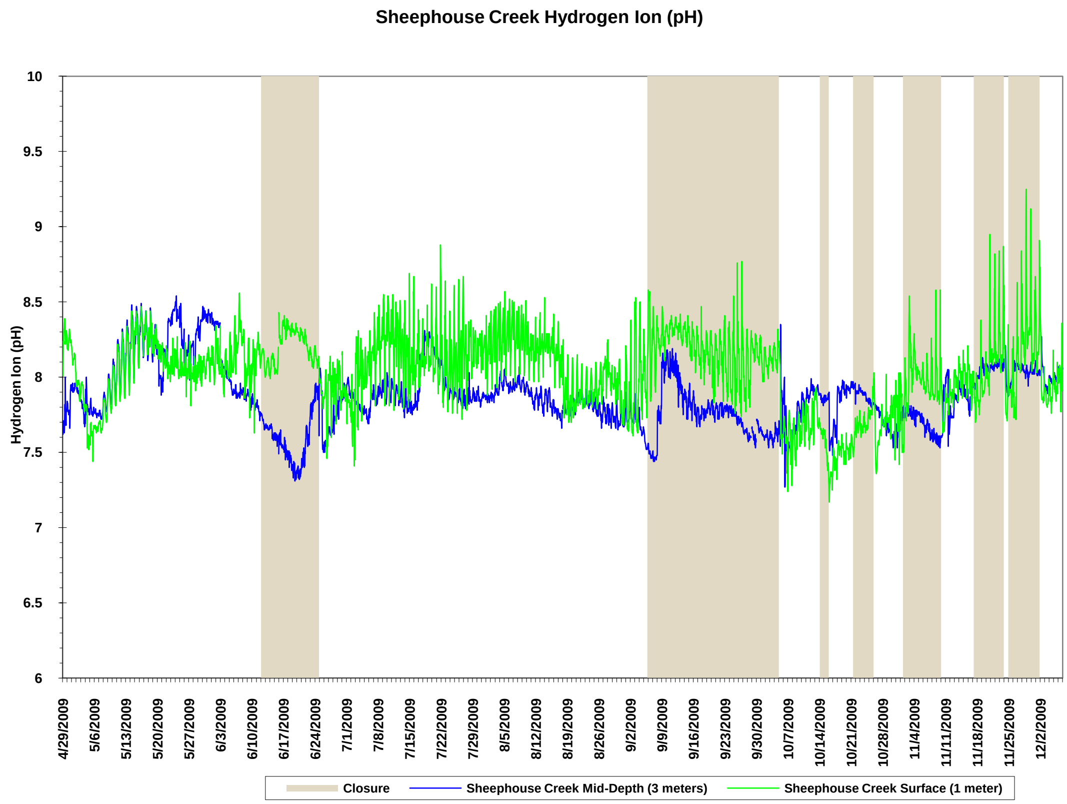


Figure 4.1.24. 2009 Russian River at Sheephouse Creek Hydrogen Ion Graph

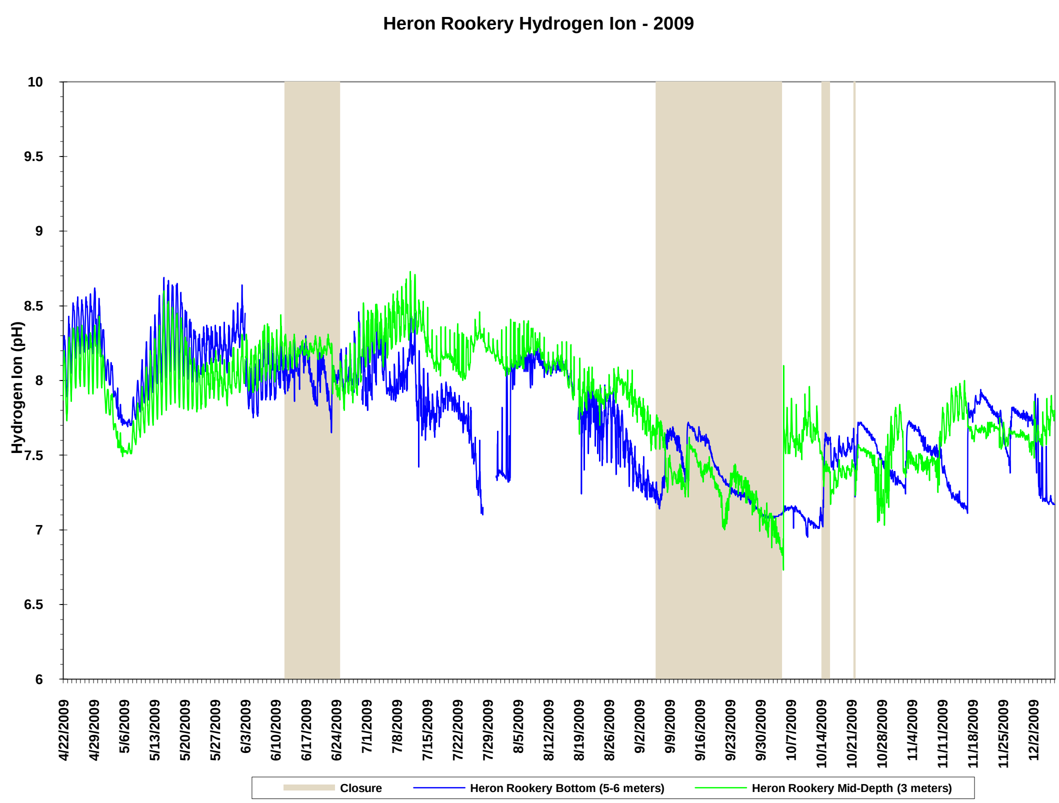


Figure 4.1.25. 2009 Russian River at Heron Rookery Hydrogen Ion Graph

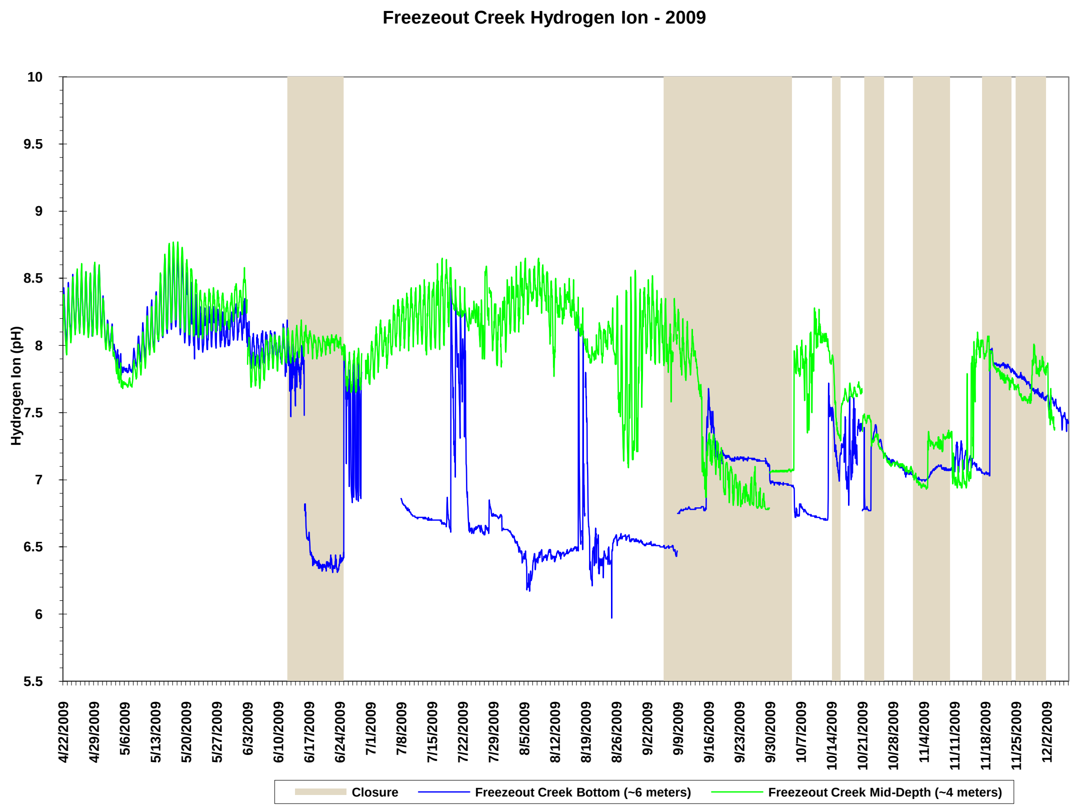


Figure 4.1.26. 2009 Russian River at Freezeout Creek Hydrogen Ion Graph

the monitoring season, with the exception of the Freezeout Creek Bottom Sonde which had a single minimum value of 6.0 pH that occurred during an anoxic event on 25 August; wherein H_2S was released into the water column (as evidenced by false DO supersaturation values in Figure 4.1.20) resulting in the low pH (Figure 4.1.26). Maximum pH values were observed to be highly consistent in the upper reach and ranged from 8.7 pH to 8.8 pH.

Nutrients

The United States Environmental Protection Agency (USEPA) has established section 304(a) nutrient criteria across 14 major ecoregions of the United States. The Russian River was designated in Aggregate Ecoregion III (USEPA, 2010). USEPA's section 304(a) criteria are intended to provide for the protection of aquatic life and human health (USEPA, 2010). The following discussion of nutrients compares sampling results to these USEPA criteria. However, it is important to note that these criteria are established for freshwater systems, and as such, are only applicable to the freshwater portions of the Estuary. Currently, there are no numeric nutrient criteria established specifically for estuaries.

Total nitrogen concentrations were generally below levels recommended for the protection of aquatic habitats; however total phosphorus concentrations were predominantly above recommended levels. The USEPA desired goal for total nitrogen in Aggregate Ecoregion III is 0.38 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). Calculating total nitrogen values requires the summation of the different components of total nitrogen; organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN), and nitrate/nitrite nitrogen. Often times, nitrogen constituent results were reported as less than the Method Detection Limit (MDL). In these instances, the MDL is used for the purposes of calculating total nitrogen estimates, and the total nitrogen value is considered less than the estimate (Tables 4.1.2 – 4.1.4). Estimated total nitrogen concentrations were observed to remain below the USEPA criteria of 0.38 mg/L, with one exception; an estimated Total Nitrogen concentration of <0.58 mg/L was recorded at the Duncans Mills station on 18 June, during the first barrier beach closure event of the season (Table 4.1.4).

The USEPA's desired goal for total phosphates as phosphorus in Aggregate Ecoregion III has been established as 21.88 micrograms per liter (µg/L), or approximately 0.022 mg/L, for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). Total phosphorus concentrations exceeded the USEPA criteria a majority of the time during both open and closed conditions at all three stations in the Estuary. Measureable levels of total phosphorus ranged from a high of 0.081 mg/L at the Jenner Station in June, to a low of 0.023 mg/L at the Bridgehaven Station in September (Tables 4.1.2 – 4.1.4). Total phosphorus concentrations were generally higher in June and July at all stations during both open and closed Estuary conditions, when late springs flows were still elevated, and tended to decrease, but remain above USEPA criteria, through the rest of the season into October with two exceptions. Samples collected at the Jenner and Bridgehaven station on October 1 had concentrations below the 0.02 mg/L MDL (<0.02). These samples were collected during the 29-day extended closure and with summer freshwater inflows below 100 cfs.

Table 4.1.2. 2009 Jenner Station Grab Sample Results

Jenner Station*	Temperature	Total Organic Nitrogen	Ammonia as N	Nitrate as N	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Enterococci	E. coli	
Method Detection Limit (MDL)		0.1	0.1	0.03		0.02	0.01	2.0	2.0	2.0	Estuary
Unit of Measure	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
5/28/2009	17.7	<0.1	0.14	2.80		0.064	<0.01	1019	<10	31	open
6/18/2009	20.2	0.14	0.14	<0.03	<.31	0.081	<0.01	1948	197	243	closed
7/9/2009	19.5	<0.1	0.12	<0.15	<.29	0.046	<0.01	24196	<10	10	open
7/30/2009	17.4	0.14	<0.10	<0.03	<.27	0.049	<0.01	8664	<10	10	open
8/20/2009	17.4	0.14	<0.10	<0.6	<.30	0.063	<0.01	8164	10	20	open
9/10/2009	15.8	<0.1	0.10	<0.03	<.23	0.026	<0.01	1723	10	63	closed
10/1/2009	16.4	<0.1	<0.10	0.069	<.27	<0.02	<0.01	1291	41	20	closed

* results are preliminary and subject to final revision.

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus: 0.02188 mg/L (21.88 ug/L)
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L)
Turbidity: 2.34 FTU/NTU

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Enterococcus: 61 per 100 ml
E. Coli: 235 per 100 ml

Chlorophyll a

In the process of photosynthesis, *chlorophyll a* - a green pigment in plants, absorbs sunlight and combines carbon dioxide and water to produce sugar and oxygen. Chlorophyll a can therefore serve as a measureable parameter of algal growth. Qualitative assessment of primary production on water quality can be based on chlorophyll *a* concentrations. A U.C. Davis report on the Klamath River (1999) assessing potential water quality and quantity regulations for restoration and protection of anadromous fish in the Klamath River includes a discussion of chlorophyll *a* and how it can affect water quality. The report characterizes the effects of chlorophyll *a* in terms of different levels of discoloration (e.g., no discoloration to some, deep, or very deep discoloration). The report indicated that less than 10 µg/L (or 0.01 mg/L) of chlorophyll *a* exhibits no discoloration (Deas and Orlob, 1999). Additionally, the USEPA criterion for chlorophyll *a* in Aggregate Ecoregion III is 1.78 µg/L, or approximately 0.0018 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). However, it is important to note that the EPA criterion is established for freshwater systems, and as such, is only applicable to the freshwater portions of the Estuary. Currently, there are no numeric *Chlorophyll a* criteria established specifically for estuaries.

Chlorophyll a concentrations were less than 0.01 mg/L at all stations during all sampling events, the level recommended to prevent discoloration of surface waters (Tables 4.1.2 – 4.1.4). However, the laboratory detection limit was not low enough to detect concentrations that may exceed EPA recommended levels in freshwater portions of the Estuary.

Table 4.1.3. 2009 Bridgehaven Station Grab Sample Results

Bridgehaven Station*	Temperature	Total Organic Nitrogen	Ammonia as N	Nitrate as N	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Enterococci	E. coli	
Method Detection Limit (MDL)		0.1	0.1	0.03		0.02	0.01	2.0	2.0	2.0	Estuary
Date	°C	mg/L	mg/L	mg/L		mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
5/28/2009	19.1	<0.1	<0.06	<0.03	<.19	0.069	<0.01	2359	10	30	open
6/18/2009	21.6	<0.1	0.13	<0.03	<.26	0.077	<0.01	882	41	161	closed
7/9/2009	21.3	<0.1	0.07	<0.03	<.20	0.061	<0.01	15531	<10	<10	open
7/30/2009	18.0	<0.1	<0.10	<0.03	<.23	0.038	<0.01	17329	10	41	open
8/20/2009	18.5	<0.2	<0.10	<0.3	<.33	0.042	<0.01	19863	<10	<10	open
9/10/2009	16.2	<0.1	<0.10	<0.03	<.23	0.023	<0.01	855	84	74	closed
10/1/2009	16.8	<0.1	<0.10	<0.03	<.23	<0.02	<0.01	3654	30	62	closed

* results are preliminary and subject to final revision.

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus: 0.02188 mg/L (21.88 ug/L)
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L)
Turbidity: 2.34 FTU/NTU

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Enterococcus: 61 per 100 ml
E. Coli: 235 per 100 ml

Indicator Bacteria

The California Department of Public Health (CDPH) developed the "Draft Guidance for Fresh Water Beaches", which describes bacteria levels that, if exceeded, may require posted warning signs in order to protect public health (CDPH, 2011). The CDPH draft guideline for total coliform is 10,000 most probable numbers (MPN) per 100 milliliters (ml). The MPN for *Enterococcus* is 61 per 100 ml, and the MPN for *E. coli* is 235 per 100 ml. However, it must be emphasized that these are draft guidelines, not adopted standards, and are therefore both subject to change (if it is determined that the guidelines are not accurate indicators) and are not currently enforceable. In addition, these draft guidelines were established for and are only applicable to fresh water beaches. Currently, there are no numeric guidelines that have been developed for estuarine areas.

Sampling results in 2009 indicate there is a large variation in indicator bacteria levels observed through the different sections of the Estuary (Tables 4.1.2 – 4.1.4). These variations occurred under both open and closed mouth conditions and may be seasonal as well.

Table 4.1.4. 2009 Duncans Mills Station Grab Sample Results

Duncans Mills Station*	Temperature	Total Organic Nitrogen	Ammonia as N	Nitrate as N	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Enterococci	E. coli	
Method Detection Limit (MDL)		0.1	0.1	0.03		0.02	0.01	2.0	2.0	2.0	Estuary
Date	°C	mg/L	mg/L	mg/L		mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
5/28/2009	20.3	<0.1	0.07	0.11	<.28	0.060	<0.01	2603	10	20	open
6/18/2009	22.6	<0.1	0.21	0.27	<.58	0.037	<0.01	1145	41	41	closed
7/9/2009	24.2	<0.1	0.09	0.12	<.31	0.058	<0.01	6867	<10	41	open
7/30/2009	21.1	<0.1	<0.10	0.11	<.31	0.038	<0.01	10462	<10	20	open
8/20/2009	21.1	<0.2	<0.10	<0.03	<.33	0.038	<0.01	4611	20	41	open
9/10/2009	20.0	<0.1	<0.10	<0.03	<.23	0.026	<0.01	1956	31	75	closed
10/1/2009	18.8	<0.1	<0.10	<0.03	<.23	0.027	<0.01	3873	10	10	closed

* results are preliminary and subject to final revision.

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus: 0.02188 mg/L (21.88 ug/L)
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L)
Turbidity: 2.34 FTU/NTU

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Enterococcus: 61 per 100 ml
E. Coli: 235 per 100 ml

In 2009, total coliform counts were higher during open conditions in mid-summer than during closed conditions at the beginning and end of the season, including the 29-day extended closure in September and October. All three stations sampled in 2009 had at least one total coliform value above the draft guidance for freshwater beach posting of 10,000 MPN/100ml during open conditions, with the Bridgehaven station having the most exceedances at three. However, the Jenner station had the highest single value of 24,196 MPN/100 ml occurring on July 9. Total coliform values were occasionally elevated during closed conditions, but not as high as during open mid-summer conditions, and the draft guidance was not exceeded at any station when the barrier beach was closed.

Enterococcus and *E. coli* counts were generally low, but were elevated and occasionally exceeded recommended freshwater levels during closed barrier beach conditions. The draft guidance for freshwater beach posting identifies the potential for public health concerns when *Enterococcus* levels exceed 61 MPN/100ml and/or when *E. coli* levels exceed 235 MPN/100ml. During closed conditions on June 18, the Jenner station had exceedances of *Enterococcus* and *E. coli* with values of 243 MPN/100ml and 197 MPN/100ml, respectively. The Bridgehaven station had one exceedance of *Enterococcus*, with a value of 84 MPN/100ml being recorded during closed conditions on September 10. The Duncans Mills station had no exceedances of *Enterococcus* or *E. coli* during the entire monitoring season.

Conclusions and Recommendations

Overall, water quality conditions observed during the 2009 monitoring season were similar to conditions observed in previous years. The lower and middle reaches of the Estuary up to Sheephouse Creek are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. Salinities near the mouth (1st mile of the Estuary) are mostly similar to ocean salinities. Whereas, the middle portion of the Estuary (one to five miles from the mouth) is most subject to fluctuation in salinities throughout the water column due to ocean tides and freshwater inflow rates. In the middle reach of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saline to brackish layer that migrates upstream as far as the Moscow Road Bridge in Duncans Mills during summer low flow conditions. The most upstream portion of the Estuary from Duncans Mills to Austin Creek (upper one mile of the Estuary) is the only portion where a predominance of freshwater habitat is maintained throughout the summer. River flows, tides, and wind action affect the amount of mixing at various longitudinal and vertical positions within the Estuary.

When the barrier beach forms, saltwater is trapped in the lagoon and water quality conditions can undergo abrupt alteration. After closure, salinity, DO and temperature changes occur within 24 hours. After the estuary becomes stratified, the mid-depth saltwater lens traps heats (Smith, 1990; Entrix, 2004). Through natural processes, DO becomes depleted in the bottom saline layer and anoxic conditions can develop. Salinity stratification leads to reductions in DO and increases in temperature in the lower water column following closure.

During barrier beach closures, the freshwater lens deepened at the surface. Highly saline conditions were typical in the mid-depths of the lower and middle reaches of the Estuary within a few days of barrier beach closures. However, salinity levels were observed to decrease at mid-depth over time, which may be evidence that the denser saltwater was percolating out of the Estuary through the barrier beach. Conversely, brackish water was observed to extend into the lower half of the water column during barrier beach closure as far upstream as Freezeout Creek in the upper reach, providing further evidence that the salt layer was stratifying and flattening out. As the closed Estuary continued to backwater, a reduction in the hydraulic forces of freshwater inflow also appeared to contribute to the upstream migration of the salt layer. Once the barrier beach had been reopened, salinity concentrations were generally observed to increase at the Surface Sondes as the freshwater layer diminished and the Estuary became tidally influenced again.

Temperature stratification coincided with the presence of the halocline, as the saltwater was typically observed to be significantly colder than the freshwater during open Estuary conditions. Surface Sonde temperatures were observed to have the greatest degree of fluctuation due to their location at the saltwater-freshwater interface. However, temperatures were also observed to exhibit diel fluctuations based on the heating and cooling effects of night and day, as well as longer-term seasonal heating and cooling events, including barrier beach closure and reopening. When the barrier beach closed, temperatures were observed to increase in the saline layer and often exceed temperatures in the overlying surface freshwater layer. Over time, a three layer system would form with a cooler saline to brackish bottom layer that is below the effects of solar heating, a hot mid-depth layer of saline to brackish water subject to the effects of solar heating, and a cooler (but still relatively warm) freshwater layer on the surface.

Mean DO levels were typically higher in the freshwater layer than in the saline layer. However, dissolved oxygen concentrations fluctuated significantly during the monitoring season at all stations, and fluctuations were not necessarily associated with tidal cycles or a diurnal cycle. DO levels in the Estuary depend upon factors such as the extent of diffusion from surrounding air and water movement, including freshwater inflow. DO levels are also a function of nutrients, which can accumulate in standing water during an extended period of time and promote excessive plant and algal growth that utilize DO. This can reduce DO levels leading to eutrophication and affecting overall ecological health of the Estuary. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel[6]. Upwelling in coastal systems, which typically occurs from March to July, also promotes increased productivity by conveying deep, nutrient-rich waters to the surface and into the estuary through tidal action, where the nutrients can be assimilated by algae.

When the barrier beach closes, salinity stratification results in pronounced DO stratification in the closed lagoon. Supersaturation, hypoxic, and anoxic events were observed, with prolonged hypoxic and/or anoxic events occurring in the deeper portions of the Estuary through the duration of barrier beach closure. Decreasing DO concentrations were also observed in the mid-depth saline layer of the water column during barrier beach closures. However, DO levels in the freshwater at the surface of the Estuary did not appear to be negatively impacted by barrier beach closure and remained similar to open conditions (7 to 10 mg/l), or increased in some instances. Similar stratified conditions were also observed when the barrier beach was open

[6] *National Estuarine Eutrophication Assessment* by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

during neap tides or low river flows, indicating that the deeper portions of the Estuary may not be subject to mixing even during open tidal conditions.

Data collected during the 29-day extended closure showed development of stratified conditions, with a downward movement of the denser, more saline water (25-35 ppt) and the development of an increased freshwater surface layer that provided a lagoon like condition. The freshwater lens began to thicken at the surface, starting at the mouth and extending upstream. High salinity observed at the mid-depth sondes of the lower and middle reaches during open Estuary conditions began to decline within a few days of barrier beach closure and continued to decline for the duration of the closure. Furthermore, brackish water extended into the lower half of the water column in the upper reach of the Estuary during barrier beach closure as far upstream as Freezeout Creek. Salinity concentrations were persistent at the bottom of the upper reach stations, but declined at the mid-depth sondes over time.

The barrier beach was breached on the afternoon of October 5. Salinity levels declined at the Heron Rookery and Sheephouse Creek Mid-Depth sondes during an outgoing tide that occurred 12 hours after the breach. DO concentrations increased as freshwater replaced the saline layer at these stations. Subsequently, salinity levels increased at the Bridgehaven and Patty's Rock Mid-Depth sondes immediately following the drop in concentration at Heron Rookery and Sheephouse Creek and DO levels became temporarily anoxic as the out flowing saline water passed through the Bridgehaven and Patty's Rock areas. Subsequent tidal inundation maintained the high salinity levels at these stations, and DO levels were observed to recover with the return of tidal mixing in the saline layer.

Interestingly, a spike in salinity of approximately 30 ppt was observed to persist for a few hours at the Sheephouse Creek mid-depth sonde during an early morning negative tide on October 7. This spike declined to brackish conditions during the subsequent low-high and high-low tides before increasing to approximately 28 ppt during the afternoon high-high tide. DO concentrations at the Sheephouse Creek mid-depth sonde became anoxic with the salinity spike, increased temporarily, then decreased to hypoxic levels with the initial return of seawater. During subsequent tidal cycles over the next several days, DO concentrations were observed to recover to pre-closure levels in the 7 mg/L and above range.
Based on the limited data, it appears that the spike in salinity may be associated with the Mid-depth sonde dropping deeper into the Sheephouse Creek pool during the negative tide and coming into temporary contact with highly saline anoxic water that is known to persist in the bottom of the pool. However, it could also be residual anoxic saline water from upstream that did not initially flush downstream with the breaching of the barrier beach.

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4.2 Invertebrate Monitoring and Salmonid Diet Analysis

The University of Washington, School of Aquatic and Fishery Sciences' Wetland Ecosystem Team (UW-WET) is conducting studies of the ecological response of the Russian River estuary to natural and alternative management actions associated with the opening and closure of the estuary mouth. This component of the Biological Opinion study is designed to evaluate how different natural and managed barrier beach conditions in the Russian River estuary affect juvenile salmon foraging and their potential prey resources over different temporal and spatial scales that frame changes in estuarine conditions under different barrier beach (open/closed bar) states. The study is designed to address both: (1) systematic sampling coincident with juvenile salmon entrance to and residence in the estuary, and (2) "event" response to stochastic (and programmed) changes in estuary entrance conditions. Systematic sampling is intended to capture the natural ecological responses (prey composition and consumption rate) of juvenile salmon and availability of their prey resources (insect, benthic and epibenthic macroinvertebrates, zooplankton) under naturally variable water level, salinity and temperature conditions in the estuary. Event sampling is designed around planned (e.g., initial years) or stochastic (later years) opening of the estuary's entrance (breaching of entrance sand bar). We are building on and complementing the Water Agency's on-going and planned monitoring and studies of juvenile salmon by integrating the study design with our investigation of fish foraging and ultimate performance as a function of prey availability.

Using this approach, we are addressing four component tasks relative to estuary entrance conditions: (1) Diet Composition—documentation of diet composition of juvenile salmonids; (2) Prey Resource Task—assessment of invertebrate (insect, benthos, epibenthos) prey resource availability from representative aquatic and riparian ecosystems and segments of estuary; (3) Zooplankton Response Task—evaluation of zooplankton assemblages and dynamics; and (4) Bioenergetics Modeling and Synthesis—bioenergetic modeling of juvenile salmon performance and synthesis/interpretation.

Methods

Sampling Sites

Sampling for fish diet and prey availability was synchronized with established Water Agency sampling sites distributed in lower, middle and upper reaches of the estuary that were established by water quality measurements; dissolved oxygen, temperature and salinity (Fig. 4.2.1; Church 2009, personal communication). Nine sites (three in each reach) were sampled for juvenile salmon by the Water Agency (see *Beach Seining* section) – (1) River Mouth; (2) Penny Island; (3) Jenner; (4) Patty's Rock; (5) Willow Creek; (6) Sheephouse Creek; (7) Heron Rookery; (8) Freezeout Creek; and (9) Cassini Ranch—of which the seven upper estuary sites (#3-#9) provided diet samples. Invertebrate prey availability was sampled at either four or five (only four in July) of those sites—(1) River Mouth; (2) Patty's Rock; (3) Willow Creek; (4) Freezeout Creek; and, (5) Cassini Ranch (excluding insect fallout traps)—where the greatest number of steelhead were caught in each of the three reaches.

Juvenile Salmon Diet Sampling

Diets of up to ten (although often even the minimum of five fish were difficult to procure) juvenile steelhead ≥55 mm FL were obtained from the monthly to semi-monthly Water Agency beach seine samples; collections of juvenile Chinook have been archived for later processing and the number of coho was insufficient to process for diet analyses. Stomach lavage (Foster 1977; Light *et al.* 1983) was performed on each fish. As per the Water Agency field protocols, fork lengths and weights were taken from each fish and the fish was scanned for a PIT tag and tagged if no previous PIT tag was detected. The diet contents were preserved in 10% Formalin for later laboratory processing.

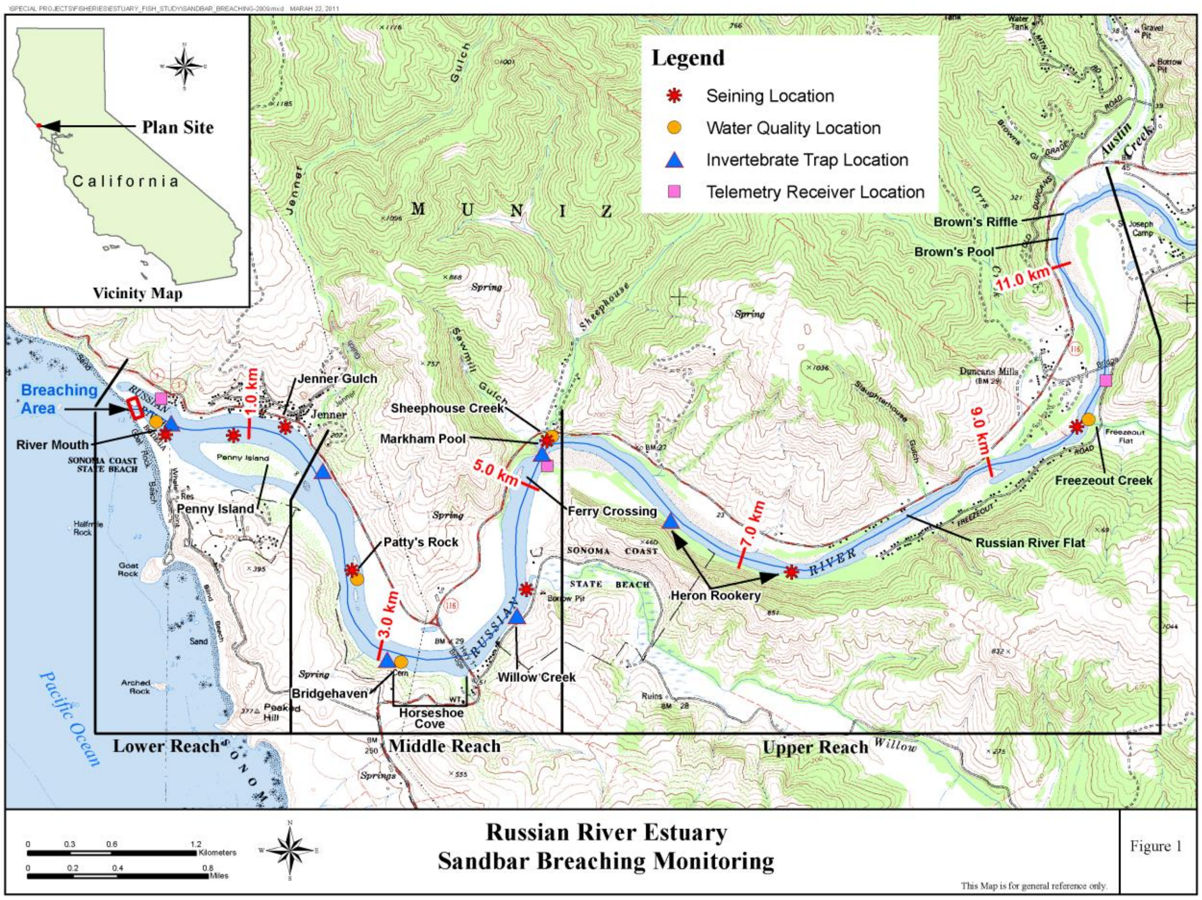

Figure 4.2.1. Locations of sampling stations for juvenile salmon diet (seining location) and prey resources (insect fall-out traps, benthic cores; epibenthic tows; zooplankton net hauls) in three reaches of the Russian River estuary, northern California, in 2009.

Prey Resource Sampling

We conducted prey resource sampling every three weeks, on each week prior to Water Agency beach seine sampling.

Epibenthos

Estuarine epibenthic organisms were sampled using a 0.5m x 0.25m rectangular net equipped with 106-µm mesh Nitex mesh. The net was dropped ten meters perpendicular from shoreline, either from a boat or walked out depending on the depth of the water. This sampling was repeated five times for each sampling trip at each site. Captured organisms were preserved in 10% buffered Formalin until laboratory analysis.

Benthic Infauna

Benthic organisms were sampled using a 0.0024-m^2 PVC core tube with a suction cup on top that can be removed. Samples were obtained by inserting the coring tube 10 cm into the sediment, placing the suction cup over the core and then removing the core from the substrate. The sediment core was preserved in 10% buffered Formalin until laboratory analysis.

Emergent and Drift Insects

We sampled emergent aquatic insects using insect fall-out traps (IFT) and a neuston net. The insect fall-out traps were 51.7 cm x 35.8 cm x 14 cm plastic bins that were filled approximately half-way full with soapy water. The fall-out traps were set on a PVC pipe platform for stability at the ground surface along the shoreline. Bamboo stakes or PVC pipe, depending on river currents, were inserted vertically around the bin and a monofilament line was attached to PVC to allow the bin to move up and down with the tides and not tip over. Five traps were deployed at haphazard distances along the shoreline and left out at each site for a total of 48 hours.

We also used the neuston net to sample the drift insects along the shoreline. The net was the same 0.5-m x 0.25-m net as used for epibenthic sampling. The net was pulled by hand in approximately 15-20 cm deep water along the shoreline, making sure to capture the top of the water column. Five haphazard samples were obtained with the neuston net, at 10 m length each.

Zooplankton

Zooplankton was sampled using a vertical water column haul with a 0.33-m ring net with 73-µm Nitex mesh. Water quality (dissolved oxygen, temperature and salinity) was sampled at the site prior to zooplankton sampling at the deepest pool near each sample site to indicate if and where the water column was stratified. If the water column was stratified, we performed a total of six vertical hauls, with three being the top "fresh" layer and the other three constituting of the entire water column, to be able to separate what zooplankton were residing in which part of the water column. If the water column was uniformly mixed, which usually occurred in the upper estuary, we obtained only three net hauls from the bottom to the surface.

Sample Processing and Analyses

Stomach contents from juvenile salmon were identified to the species level if possible under a dissecting microscope. Invertebrates found in the diets of steelhead and collected in the prey resource samples were identified to species level, except for insects which were indentified to family level. Any invertebrate collected during prey sampling and not found to be part of the steelhead diet was identified to order or family level. After processing, each sample was archived at the University of Washington to allow for future review. Each of the identified prey taxa was counted (for numerical composition) and weighed (for gravimetric [biomass] composition) and the frequency of occurrence. The state of total stomach content biomass was normalized by individual fish weight to provide an additional index of relative consumption rate ("instantaneous" ration).

In addition to individual metrics of diet composition, we also calculated the Index of Relative Importance (IRI; Pinkas *et al.* 1971), wherein %Total IRI for each discrete prey taxa takes into account the proportion that prey taxa constitutes of the total number and biomass of prey and the frequency of occurrence of that taxa among in the total number of fish stomach samples:

$$IRI_i = FO_i*[NC_i + GC_i]$$

where NC is the percent numerical composition, GC is the percent gravimetric (biomass) contribution, FO is the percent frequency of occurrence for each of the prey taxa, and *i* is the prey taxa; results were expressed as a percentage of the total IRI for all prey items. We also interpret diet composition using just GC_i in order to better represent the bioenergetic contribution of prominent (from a FO_i standpoint) prey.

Results

Juvenile Steelhead Diet Composition

Descriptive analyses of the diet composition of 105 steelhead captured in the estuary between June 24 and September 3, 2009 indicate that epibenthic crustaceans (amphipods, isopods, mysids) and aquatic insects (water boatmen) were the typical and dominant prey in most samples. Juvenile steelhead between 56-99mm in (fork) length preyed on 32 taxa, six of which constituted >5% of the numerical composition and gravimetric composition and 7% of those prey occurred in >5% of the sample; however, only two taxa constituted >5% of the Total IRI (Fig. 4.2.2). Juvenile and adult stages of the benthic-epibenthic amphipod *Americorophium spinicorne* was the most commonly and numerically prevalent prey (54% Total IRI) and juvenile and adult stages of the epibenthic gammarid amphipod *Eogammarus confericulosus* provided more biomass but contributed less to prey abundance and frequency of occurrence (17.3% Total IRI). Aquatic corixid insects, the epibenthic isopod *Gnorimosphaeroma insulwere*, other aquatic insects (Ephidridae, Empididae) and adults of the epibenthic mysid *Neomysis mercedis* all occurred in more than 5% of the samples but often contributed low proportions both numerically and gravimetrically (e.g., corixids or predominantly by either just their numerical contribution (e.g., Empididae) or gravimetric (e.g., *N. mercedis*) alone. Other prey occasionally contribute >10% of the diet composition (e.g., numerically, adult Psocoptera; both numerically and gravimetrically, juvenile and Hemiptera nymph) but do not occur frequently and thus have very low % Total IRI scores.

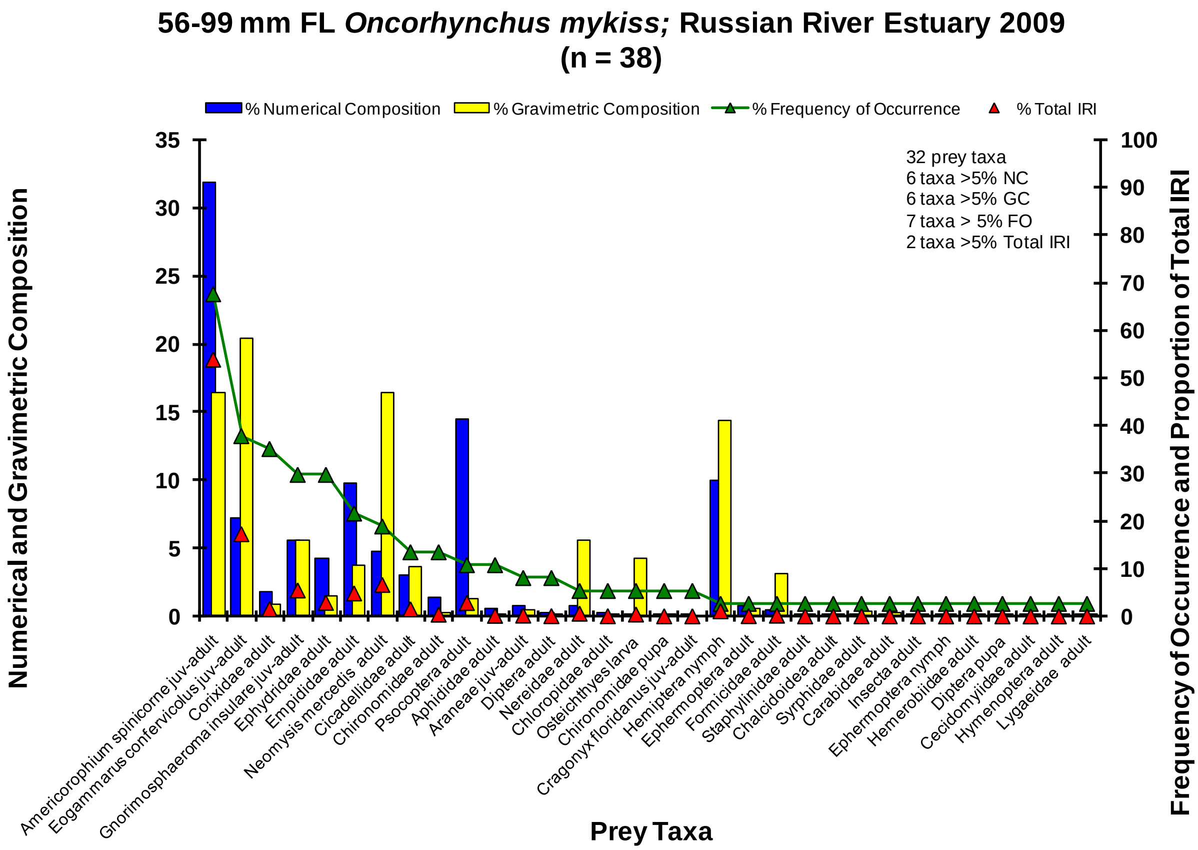

Figure 4.2.2. Index of Relative Importance (IRI) diet composition of juvenile steelhead 56-99 mm FL in Russian River estuary, 2009.

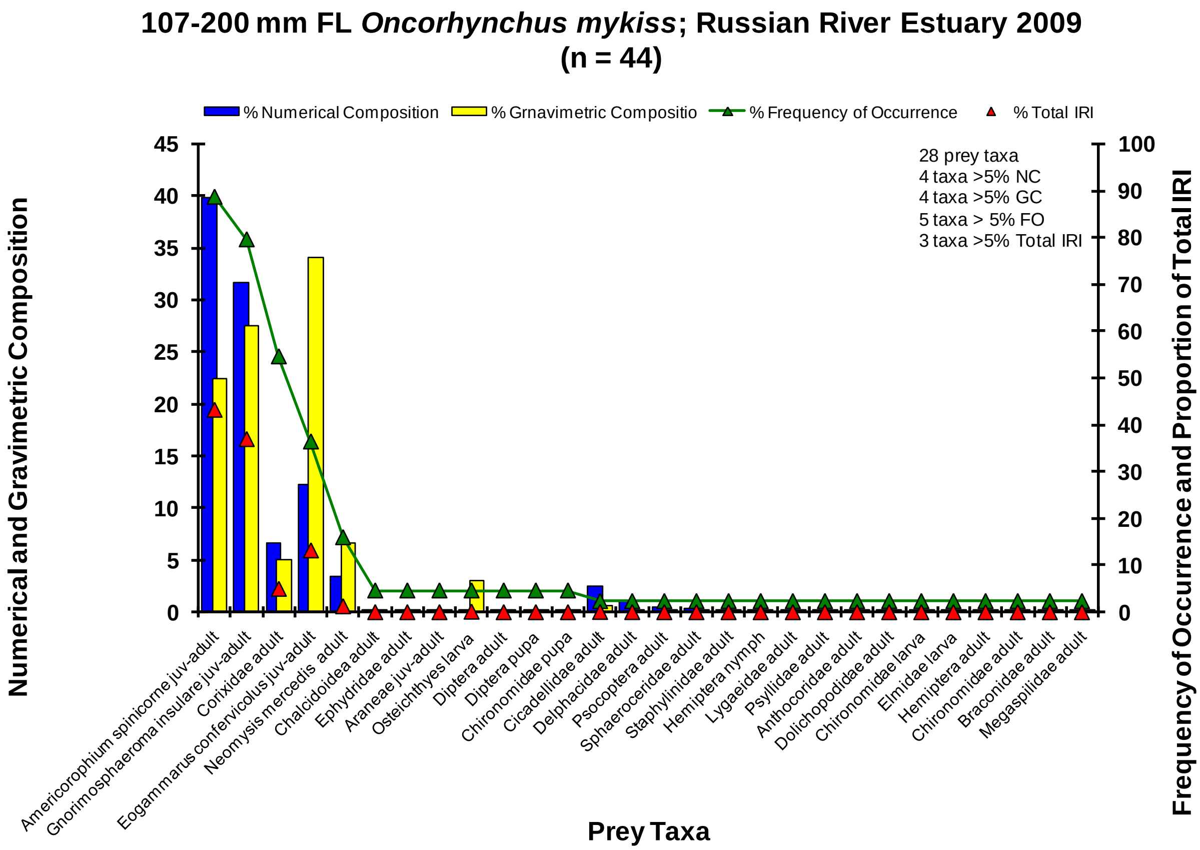

Figure 4.2.3. Index of Relative Importance (IRI) diet composition of juvenile steelhead 107-200 mm FL in Russian River estuary, 2009.

Among the 44 juvenile steelhead between 107 and 200 mm FL, the diet was more concentrated among the same top prey taxa: 28 total prey taxa, four taxa <5% for numerical and gravimetric composition, five taxa >5% for frequency of occurrence and only three taxa >5% Total IRI (Fig. 4.2.3). Juvenile and adult *A. spinicorne* and *G. insulwere* were relatively equal in term of the diet metrics, 43.3% and 37.0% of Total IRI respectively, and differed only in the numerical and gravimetric preponderance (respectively). Although less commonly preyed upon (<25%), corixid bugs and *N. mercedis* contributed 3.5% to 4.6% of both numerical or gravimetric prey composition and *E. confervicolus* contributed >34% of just the total prey biomass from 36.4% of the sample.

The largest size class of juvenile steelhead, 202-299 mm FL, illustrated an even less diverse diet spectrum, including just nine prey taxa, three taxa composing >5% of numerical and gravimetric composition, four taxa >5% frequency of occurrence and just three taxa composing >5% of the Total IRI (Fig 4). However, the dominant prey remained *G. insulare*, *A. spinicorne*, *E. confervicolus* and corixid bugs, in relative order of %Total IRI contribution. Although consumed less frequently (65.2%, compared to 95.7% for *G. insulare* and *A. spinicorne*) *E. confervicolus* dominated both the numerical (48.9%) and gravimetric (71.8%) contributions to the diet, and accounted for almost 53%Total IRI.

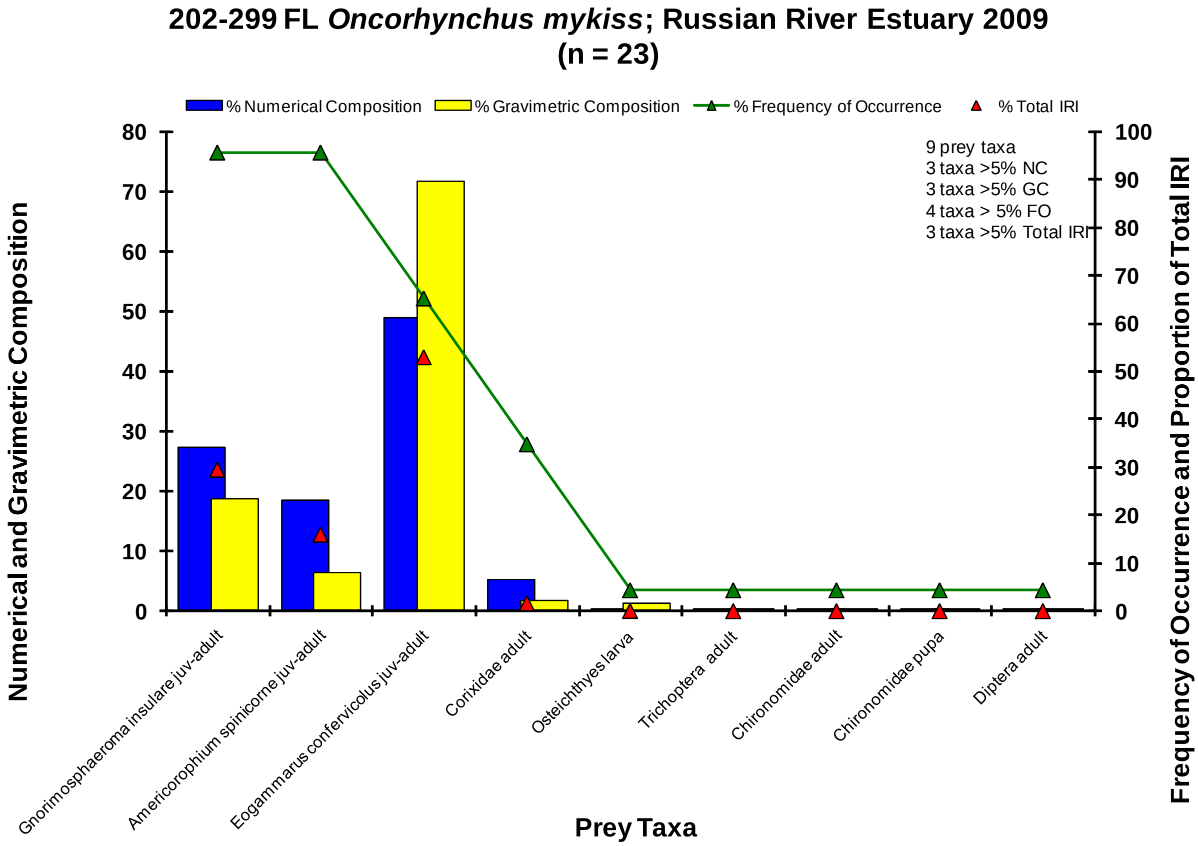

Figure 4.2.4. Index of Relative Importance (IRI) diet composition of juvenile steelhead 202-299 mm FL in Russian River estuary, 2009.

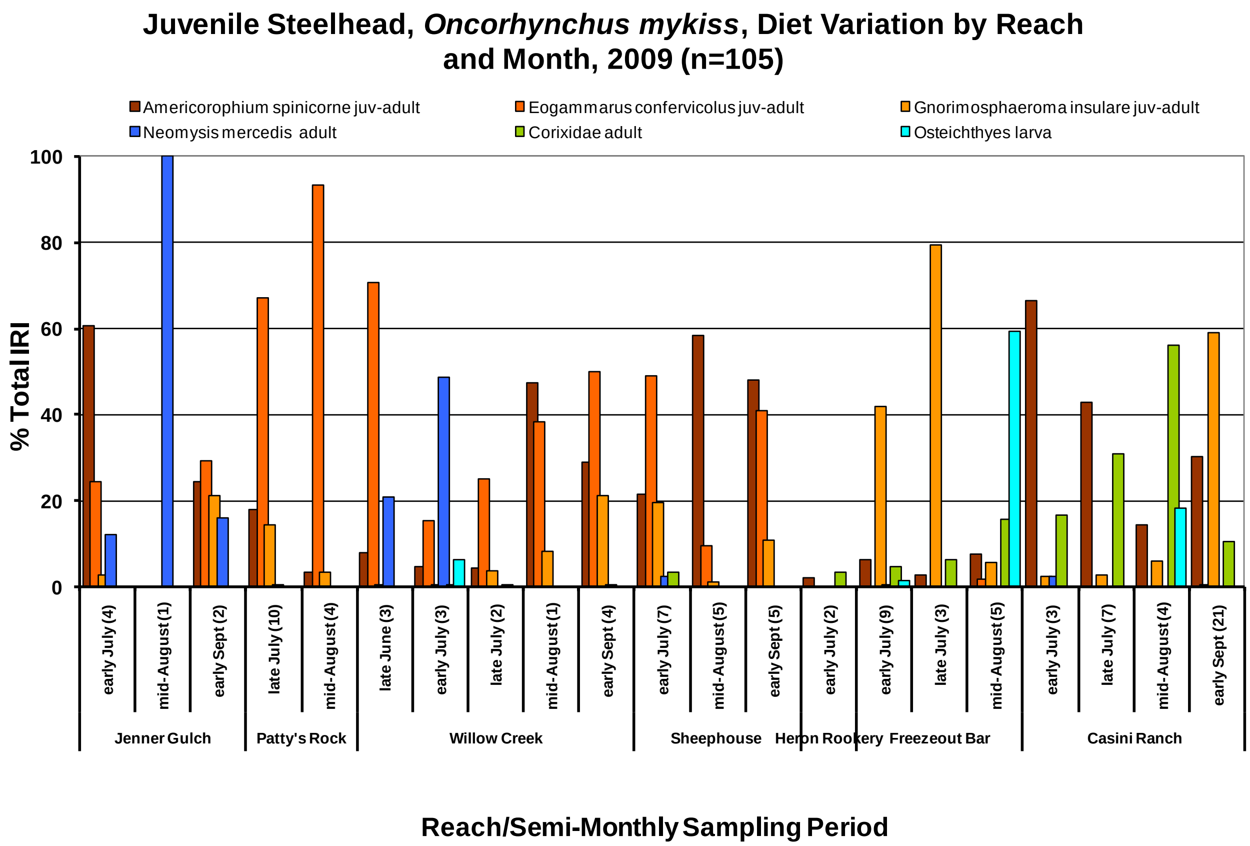

Figure 4.2.5. Mean percent total Index of Relative Importance (% Total IRI) diet composition of juvenile steelhead by month and reach of Russian River estuary, 2009.

The distribution of these five dominant prey taxa, and fish larvae (gravimetrically prominent in top ten prey taxa for two largest size classes), among all three size classes of juvenile steelhead indicates that the diet compositions shift across the estuarine gradient over time (Fig. 4.2.5). Spatially, the mysid *N. mercedis* occurs prominently only in the three sites closest to the mouth throughout our estuarine sampling sites, *E. confervicolus* tends to contribute more in the lower two reaches, while *G. insulare* was most prominent in the most up-estuary sites of the third reach. The diet contribution of *A. spinicorne* varies across all three reaches, approaching or exceeding 60%Total IRI in each reach. Corixids were almost exclusively represented in the up-estuary, Cassini Ranch sampling site. The only consistent temporal trend in taxa appearance in juvenile steelhead diets across sites was the progressive increase in proportion of corixids as the summer progressed. Trends in the gravimetric composition of prey by sampling site were represented by five taxa (Fig. 6). The epibenthic amphipods *E. confervicolus* (~45-80%) and *A. spinicorne* (~9-37%) dominated the prey biomass throughout the middle reach of the estuary and were secondary (~42% combined) only to the mysid *N. mercedis* (46%) in the lower reach. Epibenthic isopods, *G. insulare*, were present in the diet at low levels in the lower two reaches but accounted for 40-60% of prey biomass in the upper reach. *N. mercedis* constituted 45% of the prey biomass near the mouth (Jenner) and 15% in the middle reach (Willow Creek), and fish (Osteichthys) larvae consisted of almost 40% of prey biomass at Freezeout; corixids were gravimetrically evident (~13%) only at Cassini Ranch. It should be reiterated, however, that prey such as fish larvae, and the chironomids (midges) and other insects that dominated the prey biomass at Herons Rookery site were rarely consumed by steelhead, represented by only a few samples.

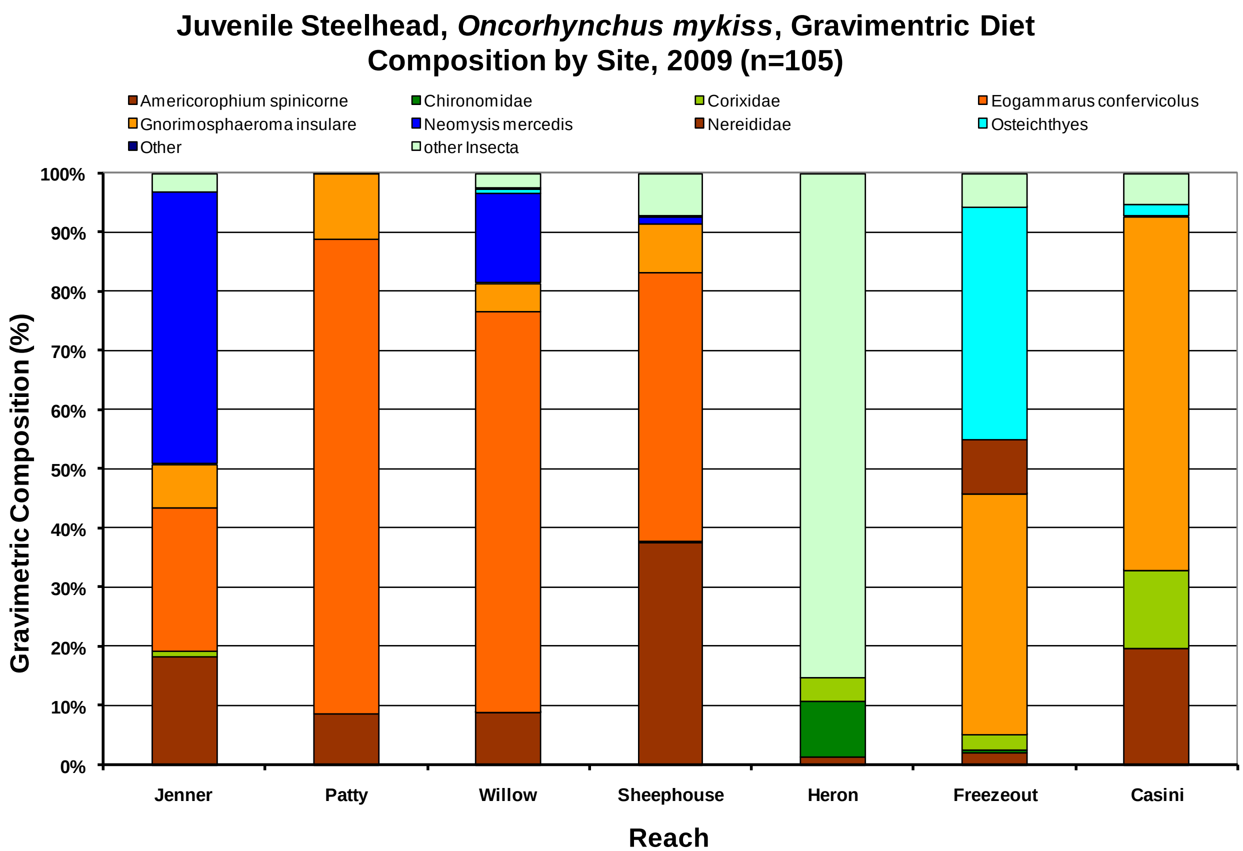

Figure 4.2.6. Gravimetric diet composition (% total prey biomass) of juvenile steelhead by site in Russian River estuary, 2009.

Gravimetric composition of juvenile steelhead diet over time further illustrated the persistence of their predation on the amphipods *E. confervicolus* (16-76%) and *A. spinicorne* (2-21%) between late June and early September (Fig. 4.2.7). The isopod *G. insulare* also constituted between 2% and 50% of prey biomass after June. The mysid *N. mercedis* appeared prominently (15-22%) in the diet only in late June and early July. Incidental contributions by nereid polychaete annelids (~10%) occurred in early July and fish larvae (7-9%) in early July and mid-August.

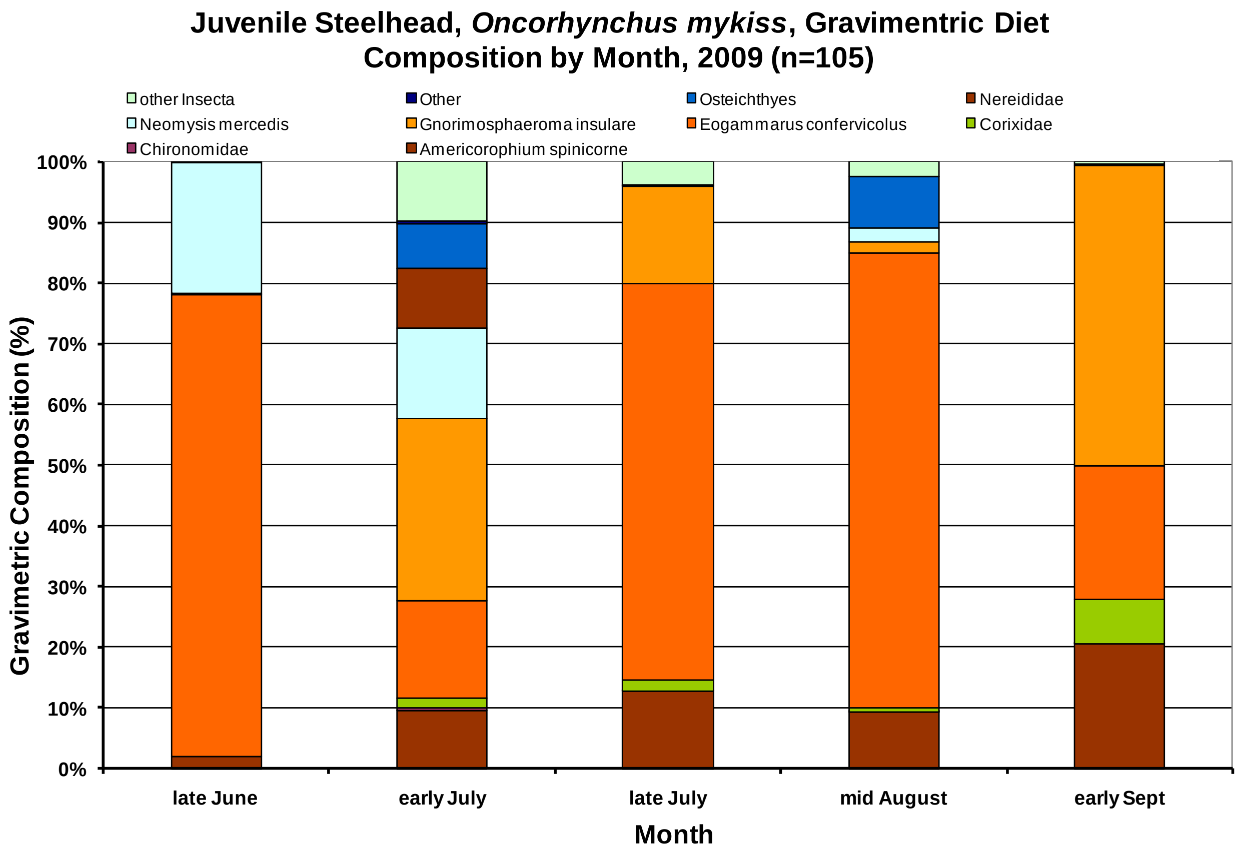

Figure 4.2.7. Gravimetric diet composition (% total prey biomass) of juvenile steelhead by month in Russian River estuary, 2009.

Although the feeding intensity of juvenile steelhead may be affected by a number of factors that we could not standardize or otherwise account for in this study, their instantaneous ration (total prey biomass/fish total biomass) provides an approximate comparison of their foraging success across the sampling sites over the duration of the sampling in 2009 (Fig. 4.2.8). Mean instantaneous ration ranged between 0.07% and 1.9% of juvenile steelhead biomass but did not illustrate any distinct trends; in some cases, instantaneous ration increased over time (e.g., Jenner, Sheephouse, Freezeout) and in some cases it was the opposite trend (e.g., Willow Creek). However, because the daily ration (which the instantaneous ration indexes to some degree) is known to decrease with fish size, normalization of instantaneous ration by fish length (Fig. 4.2.9) provides an more definitive suggestion that, irrespective of time in the sampling period, steelhead caught in the middle reach of the estuary tended to consume higher prey biomass than those captured in the upper reach, but there were too few fish from the lower reach with which to compare.

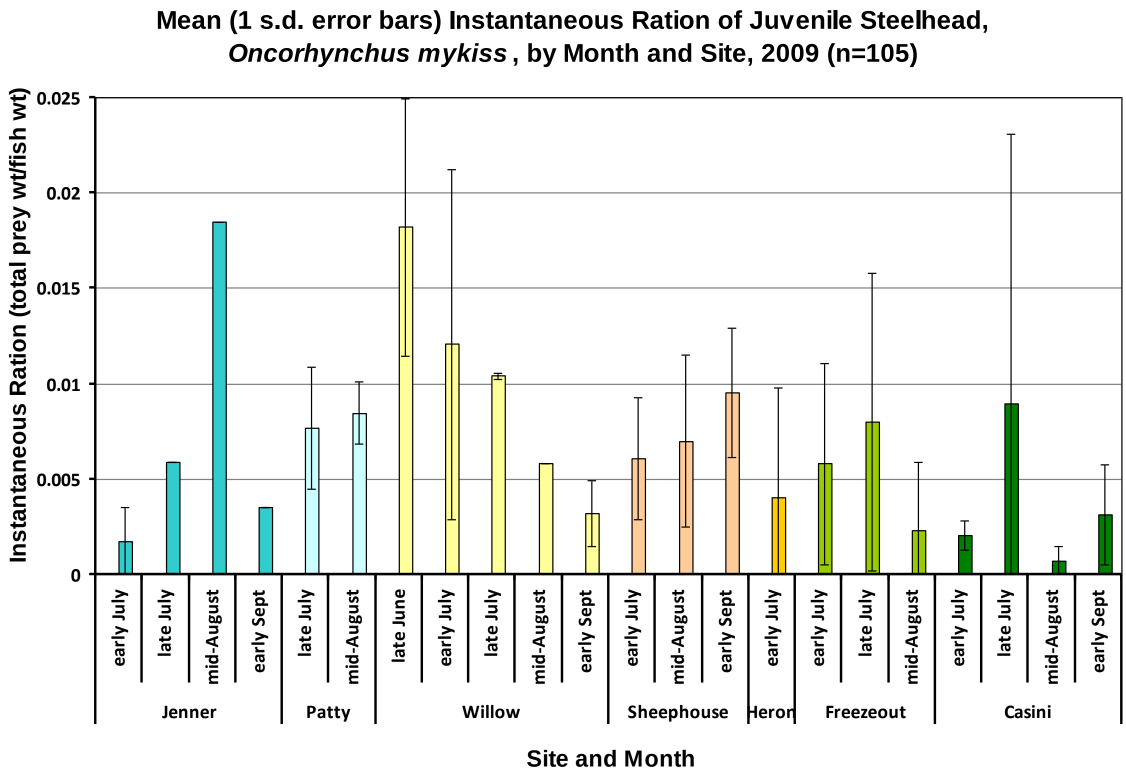

Figure 4.2.8. Instantaneous ration (total prey wt/fish wt) of juvenile steelhead by month in three reaches of Russian River estuary, 2009.

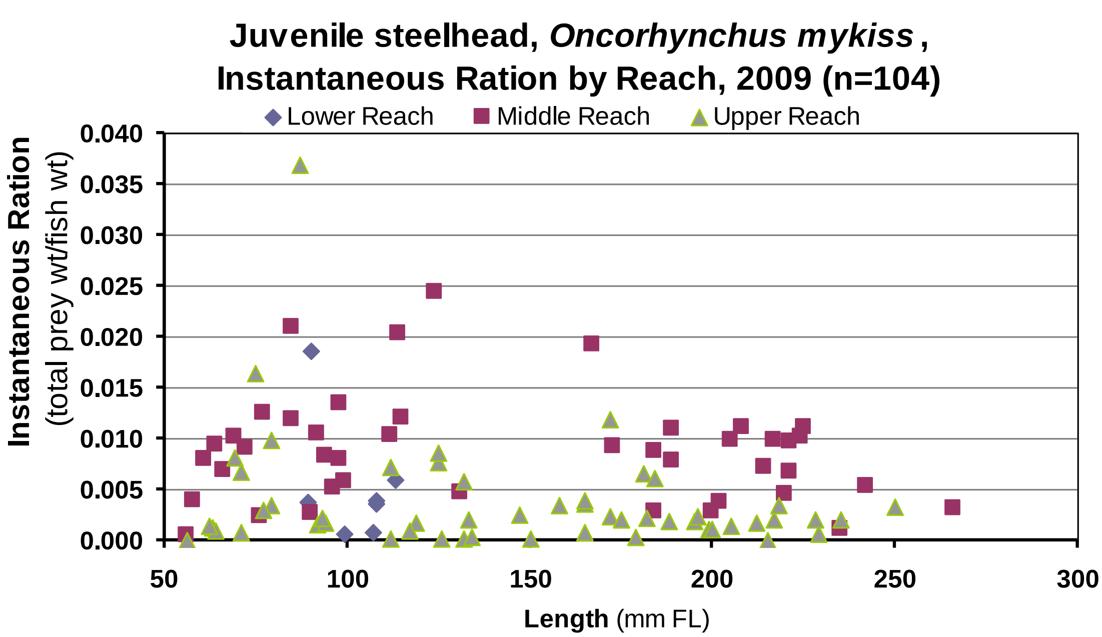

Figure 4.2.9. Instantaneous ration (total prey wt/fish wt) as a function of juvenile steelhead length in three reaches of Russian River estuary, 2009.

Prey Resource Availability

Preliminary characterization of macroinvertebrates potentially available as prey for juvenile steelhead and other salmonids is presently only completed for July samples. Processed samples include epibenthos and neuston net, benthic core and insect fallout trap sampling from shallow edges, and zooplankton net sampling from the water column in the deeper areas of the estuary.

Epibenthos

Epibenthos sampled from the 10-m transects perpendicular to shore indicated somewhat distinct assemblages at each of the four sites (Fig. 4.2.10). Many of the numerically dominant taxa were pelagic or hyperbenthic zooplankton, such as the calanoid copepods, *Eurytemora* spp., and Calanoida at the River Mouth and Patty's Rock sites, respectively. Epibenthic organisms were dominant at Willow Creek (ostracods, ~60.5%) and Freezeout (*G. insulare*, 32.4%). Notably, the gammarid amphipods, *E. confervicolus* and *A. spinicorne* were not well represented in these samples, e.g., maximum of 8.4% and 7.9% of total prey abundance, respectively.

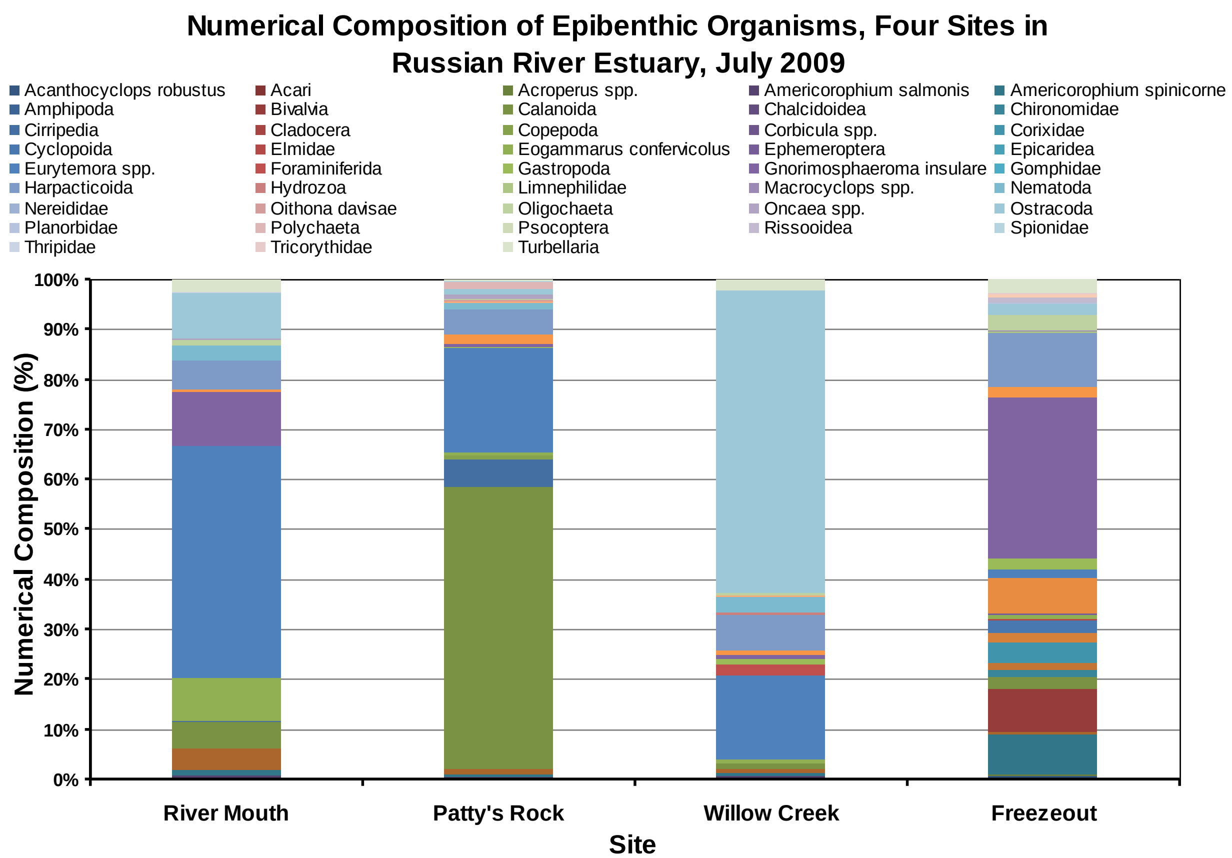

Figure 4.2.10. Numerical composition of epibenthos at three sites, Russian River estuary, July 2009.

Benthic Infauna

In contrast to the epibenthos samples, benthic infauna at the four sampling sites were relatively uniform in numerical composition (Fig. 4.2.11). Typical infauna—oligochaetes, nematodes, turbellarians—that do not usually appear in juvenile salmon diets varied across the four sites, but prominent prey of steelhead were usually well represented at all sites. Although the amphipod *A. salmonis* never appeared prominently in steelhead diets, it was the more prevalent *Americorophium* spp., decreasing in proportion from 22% to 20% of total infauna abundance with distance up-estuary; this might be explained by the exclusive tube-dwelling habit of *A. salmonis*. *A. spinicorne* and unspecified *Americorophium* spp. were also represented, in lesser proportion than *A. salmonis*. *E. confervicolus* constituted over 10% of the infaunal macroinvertebrates abundance near the estuary mouth but diminished and disappeared by the middle reach sites. Coincident with their distribution in steelhead diets, the epibenthic isopod *G. insulare* appeared in the Willow Creek infauna and was prominent (~40% abundance) in the upper estuary reach at the Freezeout Creek site.

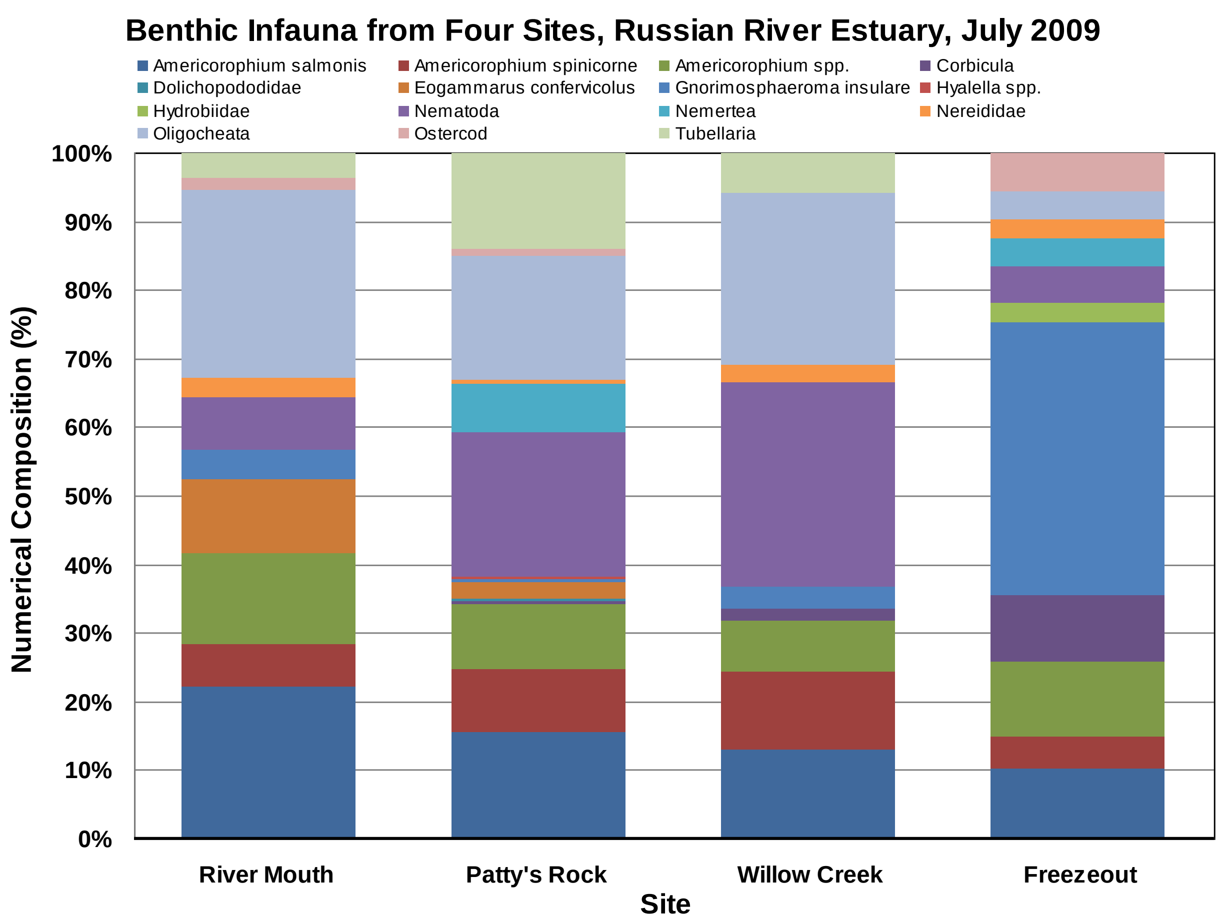

Figure 4.2.11. Numerical composition of benthic infauna at four sites, Russian River estuary, July 2009.

Emergent and Drift Insects

Neither the insect fallout traps nor neuston net sampling captured many of the prey taxa found in juvenile steelhead during 2009. The IFT samples were numerically dominated by several suborders of diperan insects—Nematocera (14-60%) and Brachycera (9-50%)—at all four sites (Fig. 4.2.12); conversely, the notable taxa of dipterans that were fed upon by steelhead, such as chironomids (midges), were not found in the IFT samples. Other insects of notable occurrence throughout the estuary included Collembola (>12%), Hymenoptera (>10%), Coleoptera (>8%), Thysanoptera (>8%) and Hemiptera (>8%); only Hemiptera and Hymenoptera ever contributed significantly, albeit rarely, to steelhead diets.

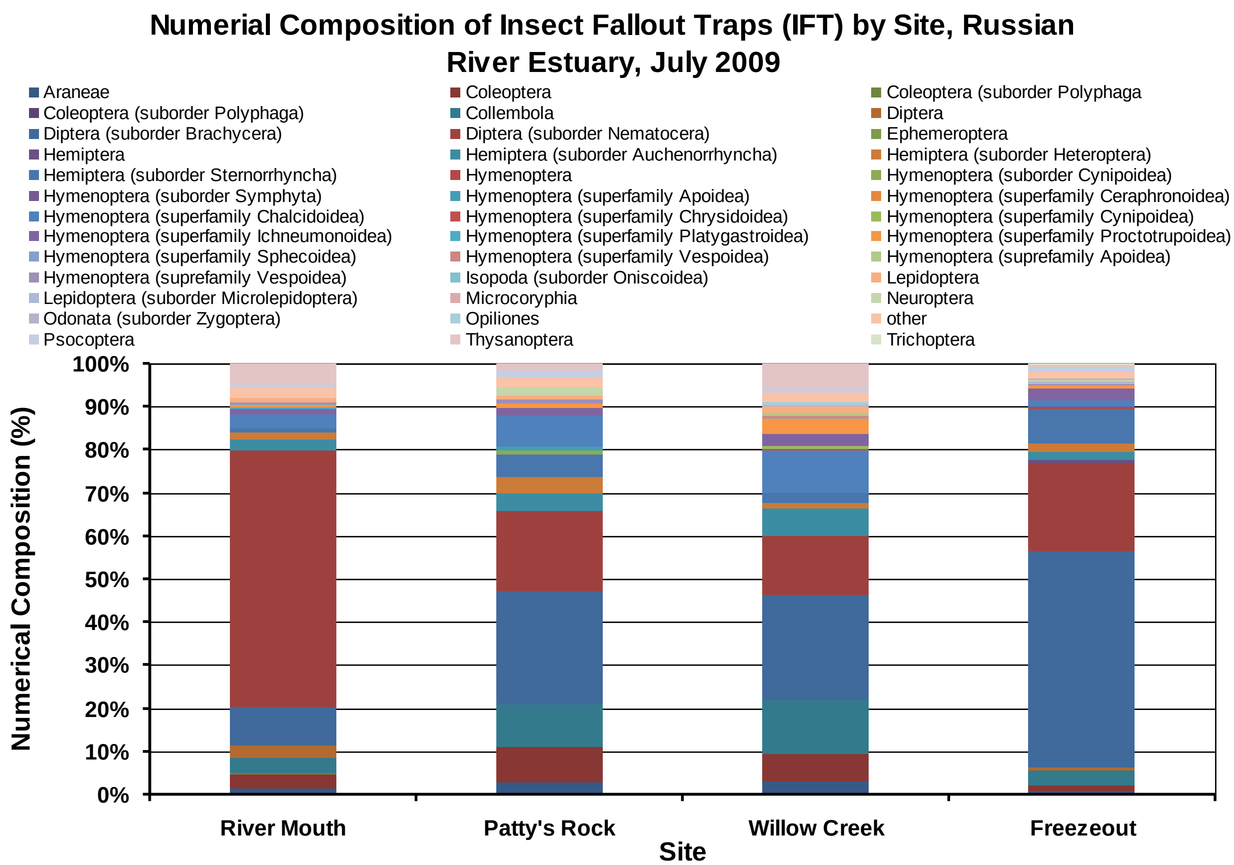

Figure 4.2.12. Numerical composition of invertebrates in insect fallout samples at four sites, Russian River estuary, July 2009.

The neuston samples were appreciably more taxa rich than the IFT samples (Fig. 4.2.13) but were also generally dominated by taxa that were relatively rare in steelhead diets. Numerically dominant taxa included the estuarine copepod *Eurytemora affinis* (4-42%, decreasing between the lower and middle reaches of the estuary), ostracods (5-59%), nematodes (4-27%), harpacticoid copepods (2-9%) and several taxa (*Acroperus* spp., *Chydorus* spp., *Eucyclops* spp.) of cyclopoid copepods (~55% in upper reach); the exceptional juvenile steelhead prey in the neuston included *E. confervicolus* (2-13%), *G. insulare* (3-27%), and *A. spinicorne* (2-5%), most of which occurred in the two sites lowest in the estuary.

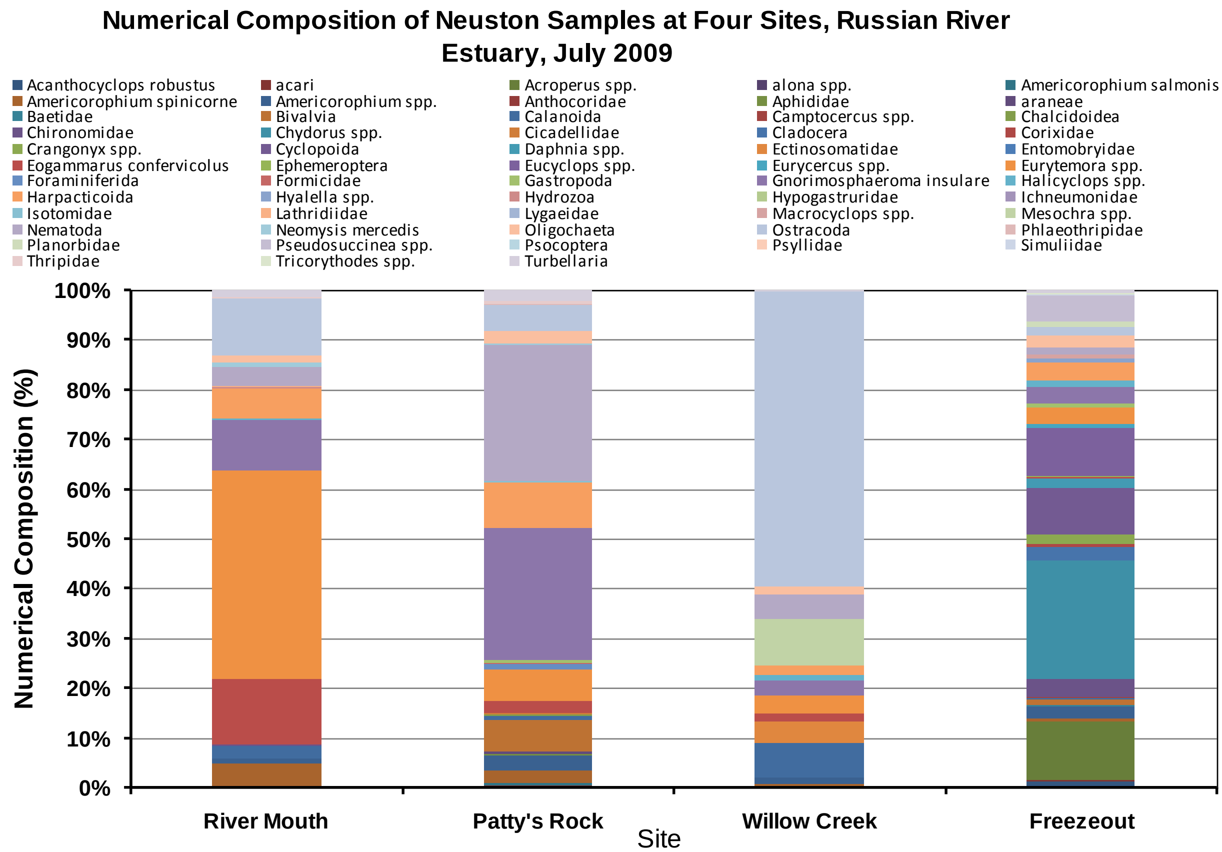

Figure 4.2.13. Numerical composition of invertebrates in neuston samples at four sites, Russian River estuary, July 2009.

Zooplankton—Pelagic zooplankton

The highest density of the major zooplankton taxa found in the water column (>112,000 m^{-3}) during sampling at four sites in July 2009 occurred at Patty's Rock, while the lowest density (~780 m^{-3}) occurred in the most up-estuary site at Freezeout Creek (Fig. 4.2.14). These samples were dominated by very small taxa—rotifers and copepod nauplii—that generally do not occur in the diets of juvenile and adult planktivorous fish (but may occur in their larvae) or in juvenile salmonids. There was no consistent pattern in the occurrence of higher densities in surface or bottom strata of the water column.

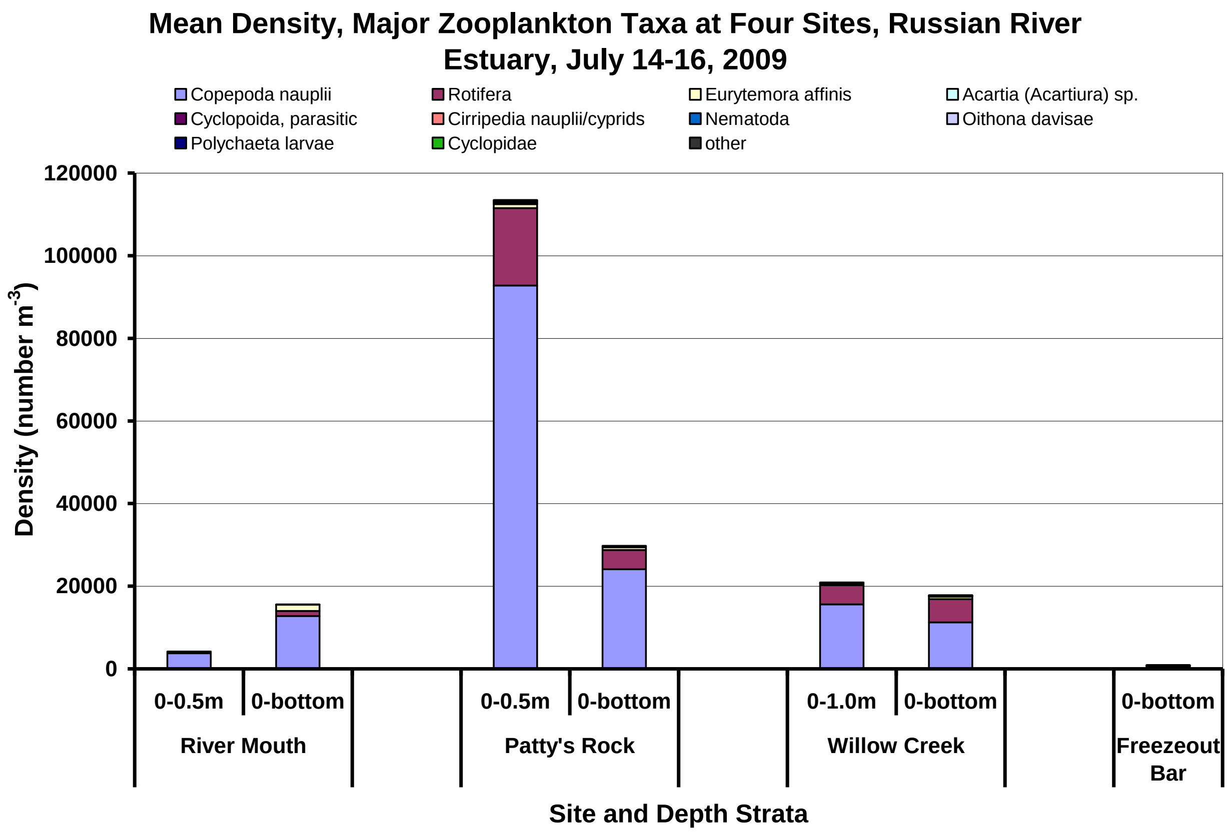

Figure 4.2.14. Cumulative mean densities of major zooplankton taxa at four stations, July 14-16, 2009.

When the prominent, small rotifers and copepod nauplii are excluded, the euryhaline calanoid copepod *E. affinis* dominates the larger-sized plankton, especially just inside the mouth of the estuary (River Mouth site) (Fig. 4.2.15). A variety of other taxa, including both calanoid and cyclopoid copepods, occurred in the middle reach of the estuary at Patty's Rock and Willow Creek sites. The introduced cyclopoid copepod *Oithona davisae* occurred most prominently at the Willow Creek station.

In terms of their affinity to marine, estuarine and freshwater regimes, euryhaline/oligohaline taxa numerically dominated the zooplankton taxa, mostly due to high abundances of *Eurytemora affinis* (Fig. 4.2.16). Mesohaline taxa such as the copepods *Acartia* sp. and *O. davisae* occurred only in the middle reach, at the Patty's Rock and Willow Creek sites. Freshwater taxa, mainly cyclopoid copepods, occurred in relatively large numbers only at the Freezeout Bar site. Marine taxa were relatively rare at all stations.

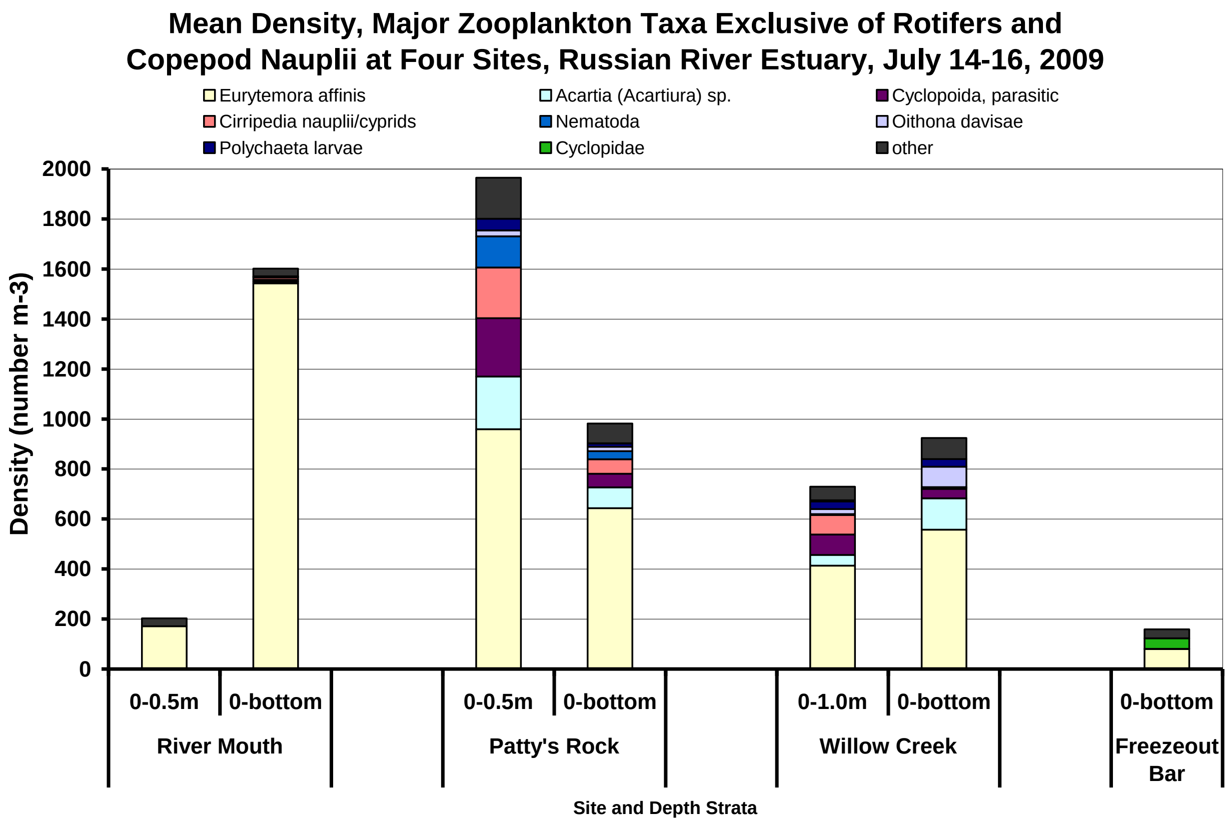

Figure 4.2.15. Cumulative mean densities of major zooplankton taxa. excluding rotifers or copepod nauplii, at four stations, July 14-16, 2009.

Conclusions and Recommendations

Juvenile Steelhead Diet Composition

Based on abundance, biomass and frequency of occurrence of diet composition of juvenile steelhead in the Russian River estuary in 2009, the primary prey are euryhaline epibenthic crustaceans — amphipods *Eogammarus confervicolus* and *Americorophium spinicorne*, isopods *Gnorimosphaeroma insulare*, and mysids *Neomysis mercedis* — and water (boatmen) bugs, Corixidae; nereids, fish larvae, chironomids are incidental. Compared to diet composition in other estuaries and habitats, emergent and drift insects and zooplankton are notably rare.

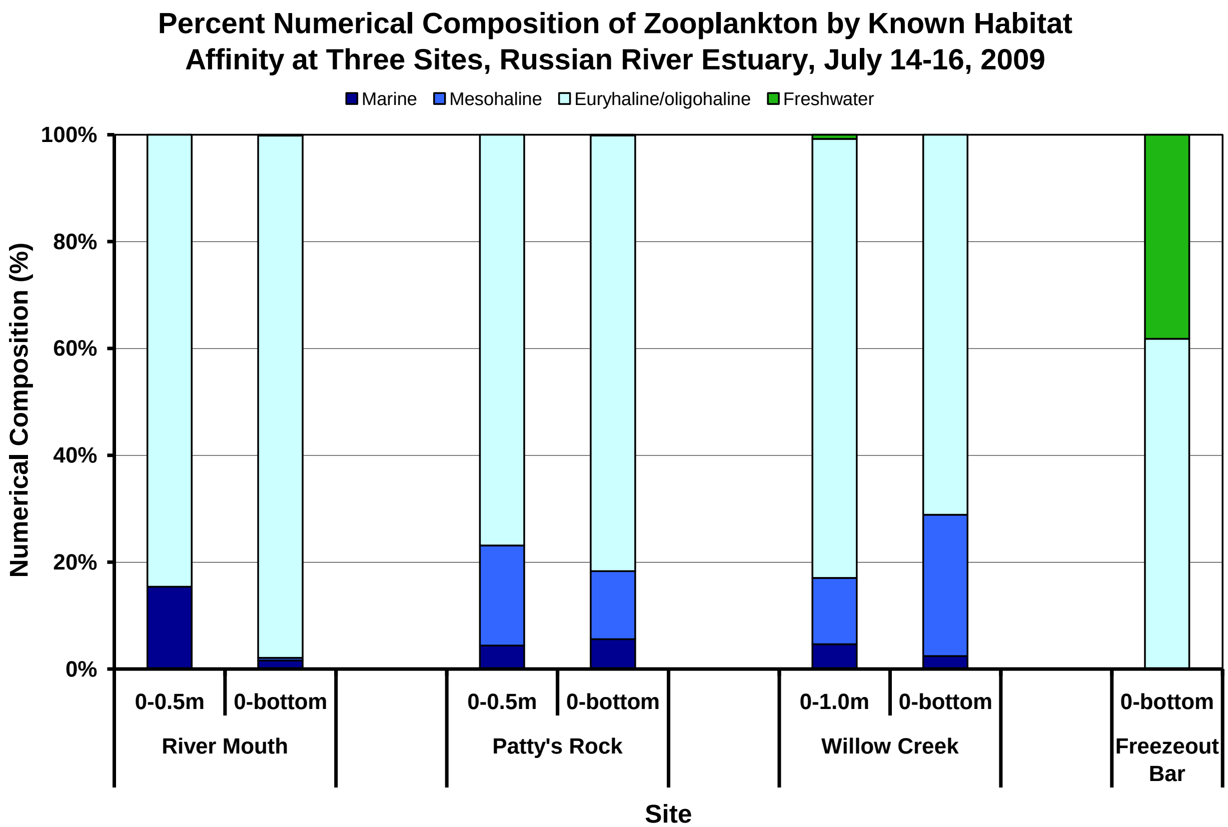

Figure 4.2.16. Percent composition of zooplankton by known habitat affinity at three stations, July 14-16, 2009. Taxa for which habitat affinity could not be determined were not included.

Prey composition over site, reach and time suggests some non-uniform availability of prey, especially mysids and *E. confervicolus* (lower reaches) and corixids and fish larvae (upper reaches); *A. spinicorne* and *G. insulare* are more evenly distributed. However, the available information does not allow us to determine whether juvenile steelhead were locally exploiting different prey in the different reaches or moving among reaches.

Juvenile Steelhead Consumption Rate

Our very preliminary and incomplete analysis (e.g., we have not factored in time of collection) suggests that foraging success may be higher in the middle reach of the estuary. However, sample sizes are not equal among reaches, with much fewer fish collected in lower reach; thus, it is impossible with the 2009 data to interpret differential performance of fish in the different estuary reaches.

Prey Availability

Based on the diet composition, epibenthic (net) sampling and, to a selective degree, benthic (core) sampling, provide direct measure of the availability of the primary prey of juvenile steelhead in the estuary. In general, the composition of macroinvertebrates in the insect fall-out (trap), neuston (net) and zooplankton (net) samples do not represent many of the common steelhead prey.

The middle reach, especially Patty's Rock site, is the location of maximum density of both euryhaline and mesohaline zooplankton, especially prominent calanoid copepod *Eurytemora affinis*. Except for fish larvae, zooplankton in general (not considering mysids as such) are not prevalent in the diets of juvenile steelhead.

Considerations and Recommendations for 2010 Sampling

Steelhead Diet & Prey Availability

Emerging evidence from the 2009 sampling suggests that shallow fringing habitats, vulnerable to estuary open/close status and management, appear to be location of steelhead prey production. Whether the shifts in this habitat with changing estuary (open/closed) conditions and management reflects movement or expansion of prey habitat or juvenile salmon foraging cannot be determined at this time. In particular, it is uncertain how foraging and thermal refugia might be distributed relate under the different estuary states. These results suggest that one adaptive change in the study design would be to reorient the focus on prey availability to epibenthic crustaceans and water bugs and add intermediate depth strata.

Other Salmonids

Given the comparable abundance of juvenile Chinook overlapping with steelhead in the estuary, it would be valuable to at least do preliminary analyses of their diet composition to see if they are exploiting a common prey resource in the same temporal and spatial patterns.

Steelhead Performance with Estuary Status

In the absence of information on the local movements of individual juvenile steelhead, we are somewhat hindered by key bioenergetic factors/indicators if we are to interpret the relative performance (e.g., growth) under different estuary states and management regimes. Critical information would include:

a) individual fish depth/temperature history;

b) individual fish movement and residence time at the site and reach scale; and,

c) individual fish growth rates (incremental).

It would be extremely valuable to acquire better/higher resolution data on at least two of these three factors before we can determine interaction between variation in prey availability and juvenile steelhead (juvenile Chinook as well) performance due to active vs. passive estuary management.

Steelhead Behavior and Performance

We would note that, while the present study design will effectively document macroinvertebrate prey availability for juvenile steelhead, interpreting the significance to steelhead in terms of their ability to convert the different prey resource regimes to growth would require some level of documentation of steelhead distribution and behavior:

1. juvenile steelhead movement, residence and growth, such as:
    - more intensive PIT tagging of fish entering the estuary, or caught in the estuary
    - greater recovery and more sites?
2. Document juvenile steelhead thermal and depth exposure
    - deploy fish with depth/temperature acoustic tags and track (fewer individuals) or detect (more individuals, detection array?)
3. Alternatives: otolith analyses for growth increment and ^{18}O analyses

4.3 Downstream Migrant Trapping

The Biological Opinion requires the Water Agency to monitor the response of presmolt steelhead to changes in estuary management by providing information about the timing of downstream movements of juvenile fish, relative abundance, and the size/age structure of the population. The Biological Opinion further states that the primary objective of the trap operation is to capture young-of-the-year (YOY) fish as they enter the estuary and that all presmolt steelhead (large enough to tag) will be implanted with PIT tags (NMFS 2008). This effort is part of a suite of Water Agency fisheries studies on the Russian River which include rotary screw trapping operations in the mainstem Russian and selected tributaries upstream of the estuary, as well as beach seining studies conducted in the estuary.

Methods

Site description

During the late spring and early summer, 2009, a fyke net was installed on a low gradient riffle between the Cassini Ranch campground and the Moscow Road Bridge at river km 10.5. This riffle is near the upstream end of the estuary but downstream of Austin Creek, a major tributary to the Russian River and an important contributor of YOY steelhead in close proximity to the estuary. At the location of the fyke net, the wetted channel width of the river was approximately 100 m wide and was typically less than 1 m deep during low tide. When a sand bar forms at the mouth of the Russian River, the water column depth in the vicinity of the fyke net can approach 3 meters. The water column is dominated by freshwater both when the river mouth is open and closed. In general, the water quality at the fyke net location is similar to the freshwater portion of the Freezeout pool which is located approximately 1 km downstream of the fyke net site (water quality in Freezeout pool has been monitored from late spring through fall with continuously-recording data loggers by the Water Agency; see the preceding chapter in this report). Water temperature at the fyke net site also appears to be well-represented by water temperature at Hacienda Bridge (USGS gauge 11467000).

Fyke Net

The configuration of the fyke net and wing walls for the 2009 sampling season consisted of a 20 m long by 2.5 m tall wing wall that stretched from the river right bank to the fyke net and a 30 m long by 2.5 m tall wing wall that stretched from the fyke net to a gravel bar located in the center of the river channel. Together, these wings formed a 30 m wide upstream facing "v" that was intended to help funnel downstream migrating fish into the fyke net and live box (Figure 1). The wing wall had a float line on top and a double lead line on bottom. Stainless steel rings spaced every 1.5 m were sewn into the net along the top and bottom of the net panels. These rings were used to attach the wing wall to metal t-posts that were driven into the stream bed. The wing walls were made from 16 mm nylon knotless stretch mesh. Although smaller mesh size is generally recommended for trapping juvenile salmonids (e.g., O'Neal 2007), the larger mesh was necessary to reduce the accumulation of drifting filamentous algae on the wing walls. We found that collapse was likely when significant algae accumulated on the wings walls.

The netting used for the fyke net was 3 mm stretch mesh. The opening of the 5 m long fyke net was 240 cm tall by 150 cm wide and stretched over a wooden frame that had 2 cm diameter vertical metal bars spaced every 12 cm. The purpose of the bars was to exclude marine mammals from entering the fyke net while still allowing fish to enter the fyke net and live box. The downstream end of the fyke net was connected to a section of 16 cm diameter PVC pipe that terminated in a rigid live box. The fyke net and live box was situated in the thalweg of the river.

The live box and fyke net was cleaned and checked daily during operation between April 29 and June 27 with the exceptions noted below (see Results). All fish captured in the live box were identified to species and enumerated. All presmolt and smolt salmonids captured were measured for fork length and weighed each day water temperatures allowed (<21°C). Additionally, a subsample of each non-salmonid was anesthetized and measured for fork length each day water temperatures allowed. All fish were released immediately downstream of the fyke net. Steelhead ≥75 mm FL were surgically implanted with passive integrated transponder (PIT) tags and released downstream to compliment additional estuarine studies being conducted by the Water Agency. Water temperature was continuously-recorded in the live box from May 15 to July 6 (beyond the end of the trapping season). Water temperature was also recorded daily with a handheld thermometer in order to guide fish handling. Water depth at a standard location on the live box was recorded daily.

Figure 4.3.1. Photograph of the estuary fyke net located approximately 400 m upstream of the Moscow road bridge, 2009. Photograph was taken during a time when the mouth of the Russian River was not blocked by a barrier beach.

Results

The fyke net was fished daily from April 29, 2009 to June 27, 2009, with the following exceptions: May 2 to May 11, when a storm event caused flows to reach 2,700 CFS at Hacienda Bridge (Figure 4.3.2); and June 18 to June 22, and June 25 when daily minimum water temperatures at the site ranged from 21.8-22.4°C (Figure 4.3.3). A sandbar formed at the mouth of the Russian River on June 12 resulting in gradually deepening water levels at the site until the sandbar was mechanically breached by the Water Agency on June 25 (Figure 4.3.2). The depth at the fyke net during this period increased from approximately 1 meter to 3 meters which made the live box extremely difficult to access by personnel.

Of the 64 steelhead captured in the estuary fyke net, 59 were presmolts (Figure 4), four were smolts, and one was a hatchery-origin adult. Seven of the 59 presmolts had a FL $\geq$75 mm with the size range for all presmolts 35-117 mm (Figure 4.3.5). We PIT-tagged two steelhead over the course of the season. Chinook smolts were the most numerous salmonid captured (n=162, Figure 4.3.4); their sizes ranged from 65-105 mm (Figure 4.3.5). Coho salmon were the least common salmonid captured (n=21, Figure 4.3.4); their sizes ranged from 95-150 mm (Figure 4.3.5). In addition to salmonids, we captured 18 other species including 815 sculpin (*Cottus spp.*). Of the sculpin, 429 (52%) exceeded 100 mm and 106 (13%) exceeded 120 mm in length.

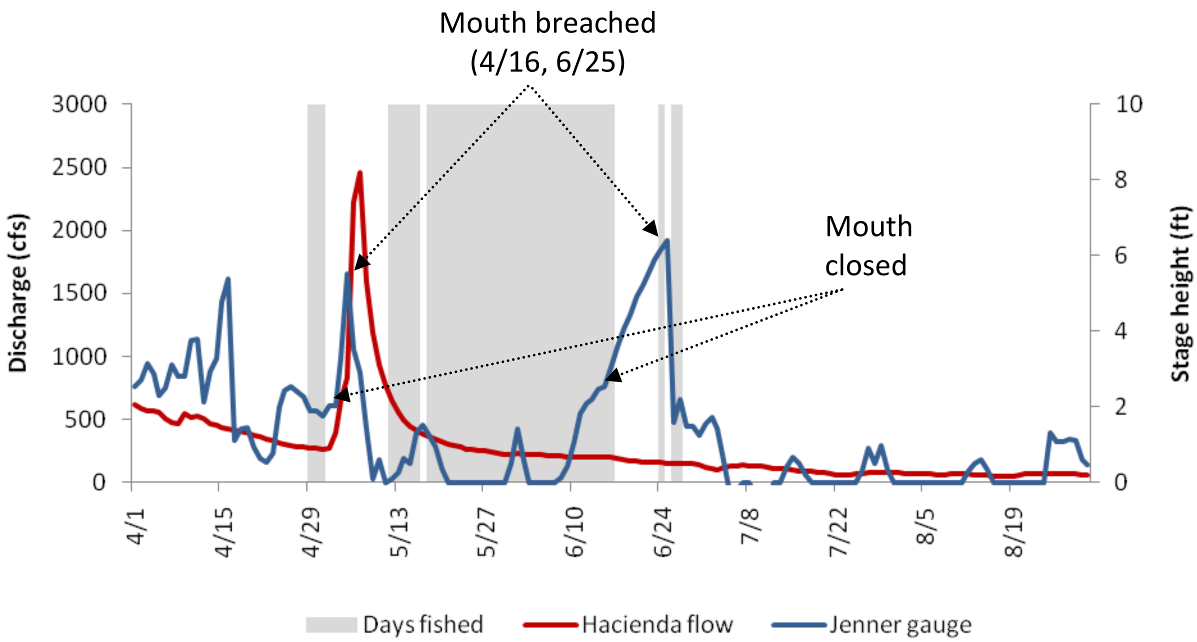

Figure 4.3.2. Discharge at Hacienda Bridge (USGS gauge 11467000), average daily stage height at Jenner, and the days the estuary fyke net fished, 2009.

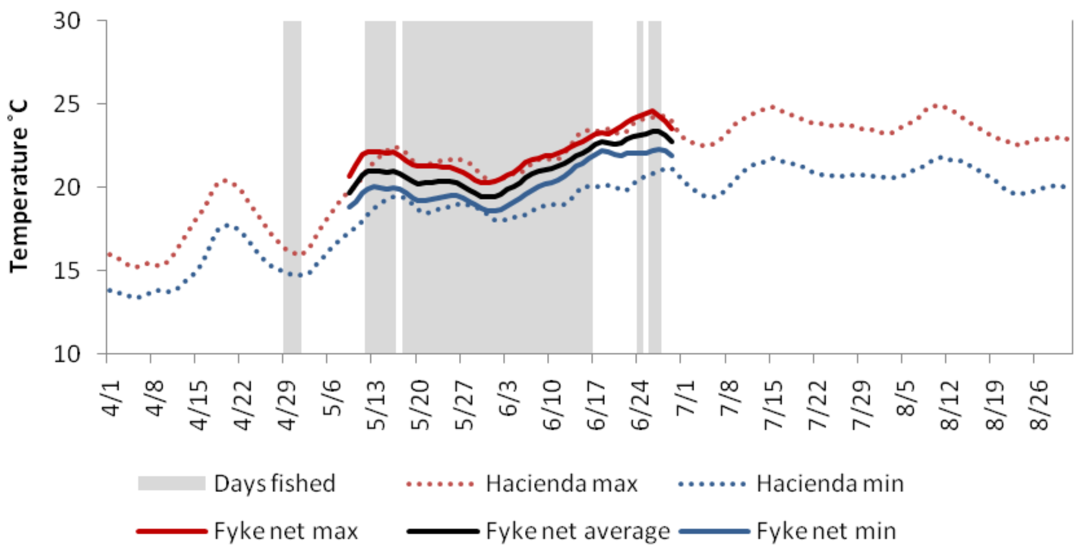

Figure 4.3.3. Minimum, maximum and average daily water temperature at the estuary fyke net, 2009. Water temperature from Hacienda Bridge (USGS gauge 11467000) is shown for comparison.

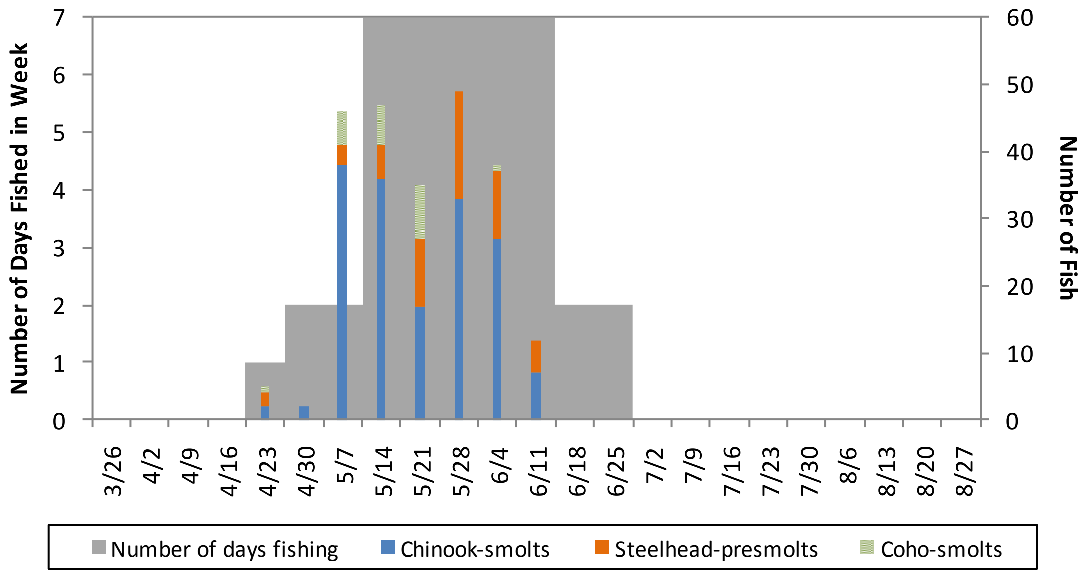

Figure 4.3.4. Weekly catch of Chinook smolts, steelhead presmolts, and coho smolts in the estuary fyke net, 2009. Note that the fyke net was installed the week of April 23 (on the day of April 29) and that this week only consisted of 1 day of sampling.

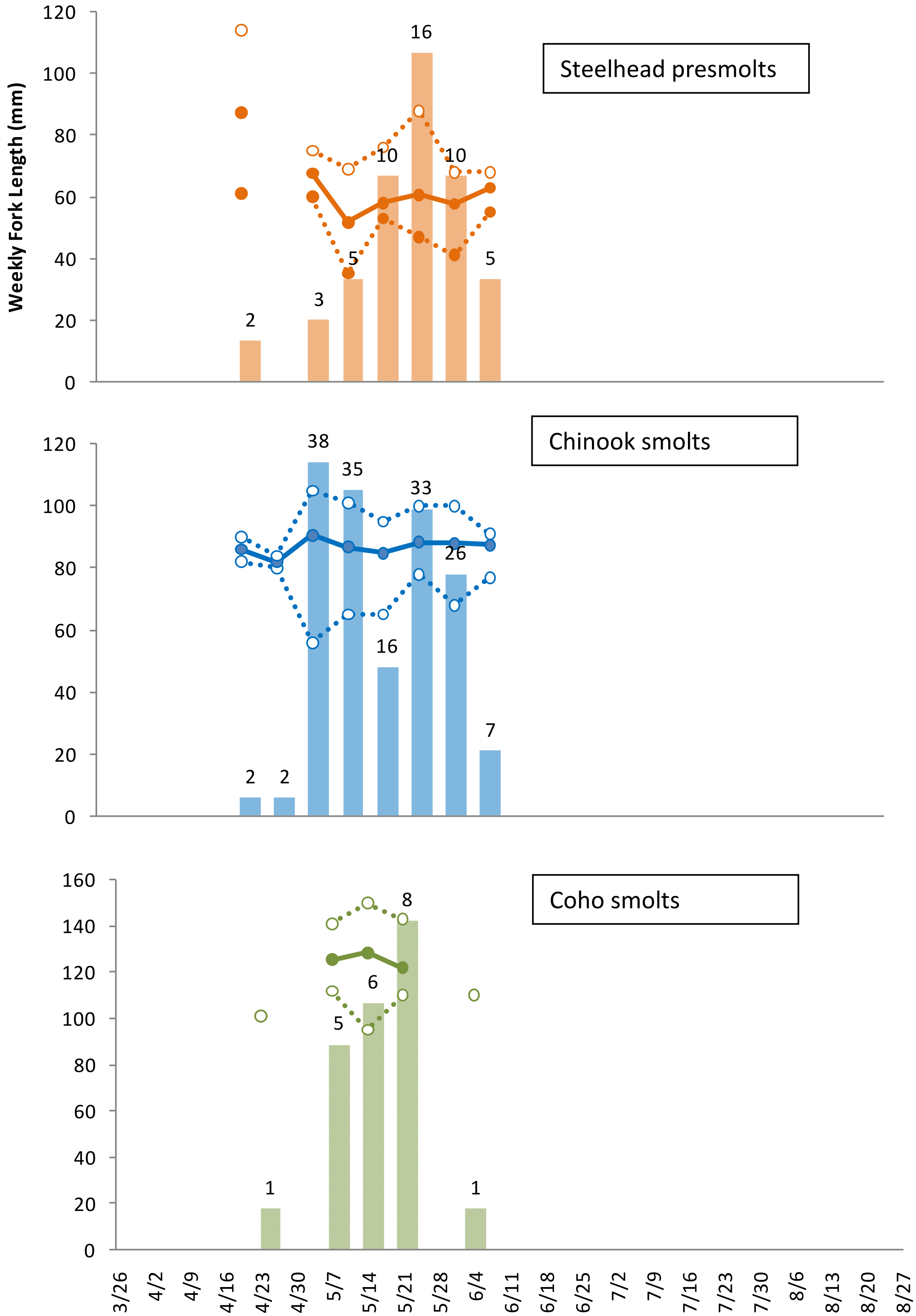

Figure 4.3.5. Sizes and sample sizes for steelhead presmolts, Chinook smolts, and coho smolts (all coho smolts captured were hatchery-origin) by week in the estuary fyke net, 2009. Solid lines represent the average and dashed lines represent the minimum and maximum. Bars and associated numbers represent weekly sample sizes.

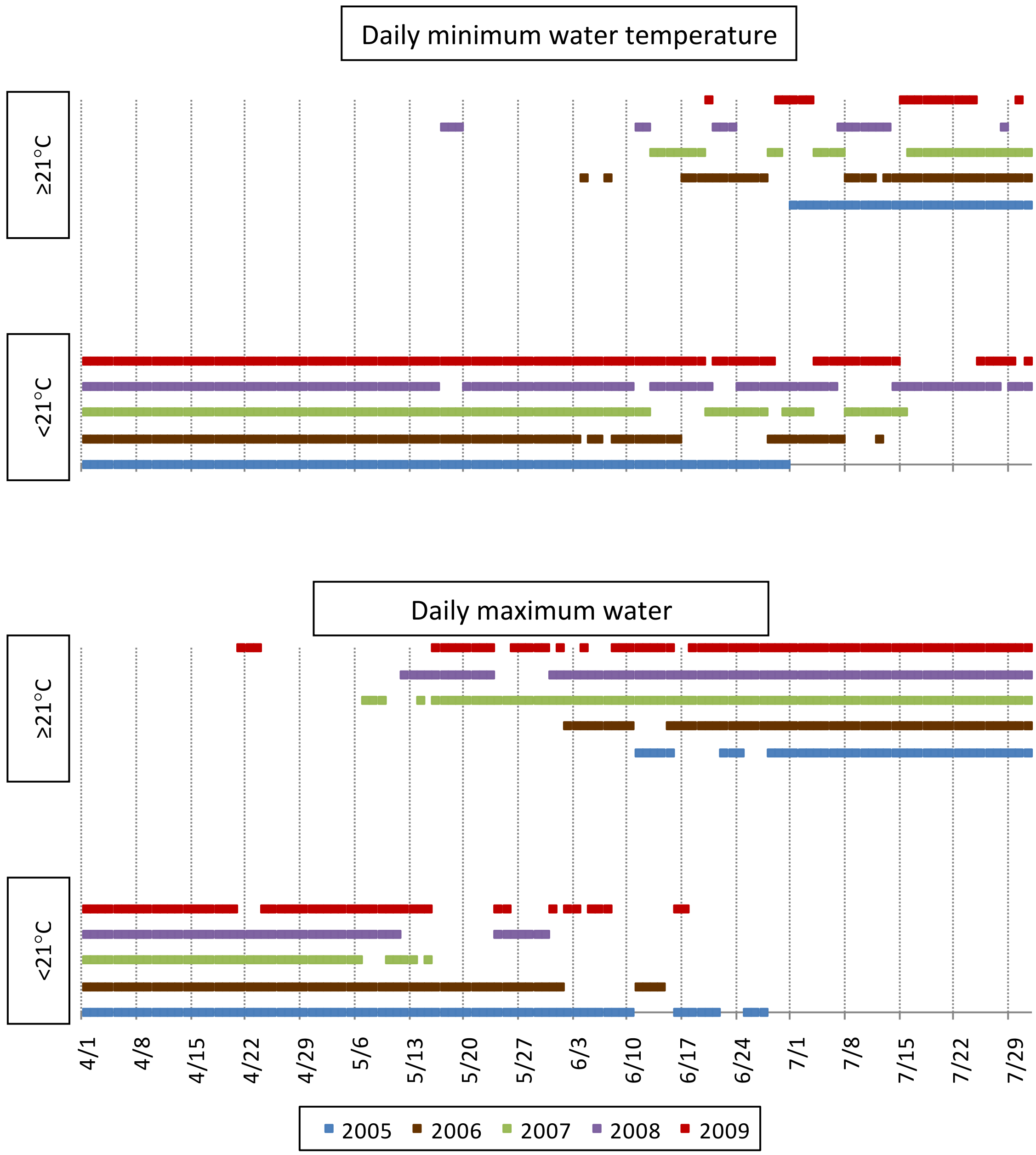

Figure 4.3.6. Indication of whether the daily minimum (top panel) or daily maximum (bottom panel) water temperature exceeded 21°C for the period April 1 to July 31, at Hacienda Bridge (USGS gauge 11467000), 2005-2009.

Figure 4.3.7. Photograph of the fyke net taken on June 20, 2009 during a closure event. Note that the top of the live box and wing walls are under water and that the top of the 2.4 m tall fyke net is approximately 0.3 m above the surface of the water.

Figure 4.3.8. A large prickly sculpin captured in the estuary fyke net on May 15, 2009.

Conclusions and Recommendations

In our estimation, the objectives of the fyke net operation stated in the Biological Opinion (i.e., providing information about the timing of downstream movements, relative abundance, and the size/age structure of steelhead YOY) was not met in 2009. The reasons have to do with: a shortened trapping season due to high flows and associated debris early in the season and high water temperatures later in the season; the wide channel (~100 m); and suspected low trap efficiency caused by generally low water velocity, reverse flow during incoming tides, and deep water in the upper estuary/lower mainstem during sandbar closure. Because of these problems, we can say very little based on the 2009 data regarding the objectives stated in the Biological Opinion.

High water temperatures in the upper portion of the estuary/lower mainstem will continue to hinder efforts to safely capture and handle fish in the vicinity of Duncans Mills. Even though we collected a limited amount of water temperature data during the 2009 trapping season (May 15- July 6), evidence suggests that water temperature at Hacienda Bridge is an excellent proxy for water temperature at Duncans Mills. We base this on an analysis of water temperature data during the period when data are available from both sites. That analysis showed that pairs of minimum daily and maximum daily water temperatures were highly linearly correlated ($R>0.81$, $df=49$; p for R, intercept, and slope all <0.0001 for both regressions; also see Figure 4.3.3). A summary of the data from Hacienda Bridge from 2005-2009 shows that while minimum daily water temperatures above 21°C were typically not persistent until mid-June, maximum daily water temperatures above 21°C were present by mid-May in three of five years and by mid-June in all five years (Figure 6). Assuming a 122 day trapping season (4/1-7/31), the proportion of the sampling period in each year from 2005-2009 that minimum daily water temperatures exceeded 21°C ranged from 13.1% to 29.5%; maximum daily water temperatures exceeded 21°C for 33.4-66.4% of the time.

The channel width (~100 m) and hydrologic characteristics of the lower mainstem/estuary in the vicinity of Duncans Mills will continue to present challenges to achieving a representative sample of salmonids moving into the estuary. Despite daily cleaning and the wing walls having a double lead line on the bottom of the net, on occasion debris loading resulted in gaps opening in seams between the net panels, and the fyke net and along the river bottom. The extent to which fish escaped through these gaps is unknown. Because of the mesh size in the wing walls (16 mm), there was also the possibility that smaller fish (e.g., steelhead YOY) could simply swim through the net. Other than early May 2009 following a late spring storm, the low gradient and wide channel of the estuary lends itself to low water velocities throughout most of the trapping season. These conditions likely allowed fish to easily enter and later exit the live box through the upstream (funnel) end and thereby escape capture. Although velocities were higher on outgoing tides, incoming tides actually resulted in reverse (“upstream”) flow. Anecdotally, we noted that catches were higher during an incoming tide. Under lagoon conditions, tidal currents ceased altogether thus reducing catches even further. The water depth during closure (up to 3 m was observed at the fyke net site in 2009) also severely limited access by personnel checking and cleaning the live box and netting (Figure 4.3.7).

Predation by sculpin on salmonids within the live box was very likely a significant problem during the 2009 trapping season (Figure 8). Numerous prickly sculpin large enough to consume YOY steelhead were captured on a daily basis. According to Quinn (2005), torrent sculpin (*Cottus rhotheus*) are capable of consuming prey items that are 60-80% of their body size. If prickly sculpin feed similarly, a 120 mm prickly sculpin could consume a salmonid up to 96 mm. Of the steelhead captured in 2009, 88% had a fork length of 80 mm or less. To evaluate whether predation by sculpin on steelhead was occurring, we placed 35 hatchery-origin, adipose fin-clipped steelhead YOY from Warm Springs hatchery in the live box. Twenty-four hours later, we used gastric lavage to recover 10 steelhead YOY from the stomachs of 9 prickly sculpin.

Because of the factors outlined regarding trap efficiency, we believe that the likelihood of succeeding at accomplishing the objectives in the Biological Opinion by repeating the monitoring approach used in 2009 is low. Further, we are concerned that continuing this effort in future years could lead to inordinately high mortality of salmonids, either through exposure to high water temperatures (coho are particularly sensitive to high temperatures) or indirectly through predation.

In 2010, the Water Agency evaluated the efficacy of remote monitoring methods as opposed to direct capture and handling of fish in the fyke net live box. We incorporated two remote monitoring methods that allowed us to detect and count fish by species and life stage. First, we incorporated a continuously-operating PIT antenna into the fyke net to allow detection of PIT-tagged fish as they passed through the fyke net. Second, because not all fish were PIT-tagged, we also record continuous video footage with an underwater video camera as fish pass through the fyke net. Although the complete results from these monitoring methods are not reported here (they will be reported in subsequent reports), these passive monitoring methods were successful at allowing detection of PIT-tagged fish and identification by species and life stage while eliminating the need to capture and hold fish in a live box. The camera system also had a measuring device so that fish lengths and age classes could be estimated. Because of the promise offered by these monitoring methods, we recommend increasing the number of presmolt steelhead that are PIT-tagged at downstream migrant traps operated upstream of Duncans Mills. Possible tributaries include Austin, Green Valley, Dutch Bill, Fife, and Hulbert Creeks. PIT-tagging steelhead in these lower-river tributaries will potentially result in a larger sample size and increased likelihood of capturing PIT-tagged fish during estuary seining surveys.

References

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4.4 Fish Sampling – Beach Seining

Water Agency staff has been sampling the Russian River Estuary since 2003 - prior to receipt of the Biological Opinion. To provide context to data collected in 2009, we present and discuss some of these previous years of data in this report. The distribution and abundance of fish in the Estuary are summarized below. In addition to steelhead, coho salmon, and Chinook salmon, we describe the catch of several common species to help characterize conditions in the Estuary.

Methods

Study Area

The Estuary fisheries monitoring area extended from the tidally influenced section of the Russian River from the sandbar at the Pacific Ocean to Duncans Mills, located 9.8 km (6.1 mi) upstream from the coast (Figure 4.2.1).

Fish Sampling

A beach-deployed seine was used to sample fish species, including salmonids, and determine their relative abundances and distributions within the Estuary. The rectangular seine consisted of approximately 5 mm (¼ inch) mesh netting with pull ropes attached to the 4 corners. Floats on the top and weights on the bottom positioned the net vertically in the water. During 2002-2006 a purse seine was used with dimensions of 30 m long (100 feet) by 3 m deep (10 feet). This seine was replaced in 2007 with a conventional seine with dimensions 46 m (150 ft) by 4 m (14 ft). The seine was deployed with a boat to pull an end offshore and then around in a half-circle while the other end was held onshore. The net was then hauled onshore by hand. Fish were placed in an aerated bucket for sorting, identification, and counting prior to release. A few non-salmonid voucher specimens were preserved in ethanol to verify identification. Salmonids were anesthetized with Alka-seltzer tablets and then measured, weighed, and examined for general condition, including life stage (i.e., parr, smolt). Salmonids were identified as wild or hatchery stock indicated by a clipped adipose fin and tissue and scale samples were collected from some steelhead. Fish were allowed to recover in aerated buckets prior to release.

Eight seining stations were located throughout the Estuary in a variety of habitats based on substrate type (i.e., mud, sand, and gravel), depth, tidal, and creek tributary influences (Figure 4.2.1). Three seine pulls adjacent to each other were deployed at each station. Stations were surveyed approximately every 3 weeks and during different tidal cycles from late May through September, annually. During 2009 an October seining survey was conducted after a prolonged river mouth closure from September 6 to October 5. These October data were not included in the standard May-September analysis, but were used to compare fish patterns before, during, and after the mouth closure.

The habitat characteristics and locations of the seining stations were:

- River Mouth: on the sandbar separating the Russian River from the Pacific Ocean, sandy substrate with a steep slope, high tidal influence
- Penny Island: in shallow water with a mud and gravel substrate, high tidal influence
- Jenner Gulch: at the confluence with a small creek, gravel substrate with a moderately-steep slope, influenced by tides and creek flows
- Patty Rock: on a large gravel bar adjacent to deep water, moderate tidal influences
- Willow Creek: in shallow waters at the confluence with a creek, gravel and mud substrate, influenced by creek flows and moderate tidal action
- Sheephouse Creek: at the confluence with a creek, gravel substrate with a moderately-steep slope, influenced by creek flows and moderate tidal action
- Heron Rookery: on a gravel bank adjacent to deep water, moderate tidal influences
- Freezeout Bar: on the opposite shore of the intermittent Freezeout Creek, gravel substrate with a moderate slope

The Austin Creek station was sampled from 2003-2005 and then was replaced with the Freezeout Bar station in 2006. The unstratified freshwater and lack of saline influences at the Austin Creek station makes it more characteristic of the freshwater mainstem of the Russian River than an estuarine environment. The Freezeout Bar station is tidally influenced and is located near Duncans Mills approximately 2.1 km (1.3 mi) downstream from Austin Creek.

Results

Fish seining studies include findings since 2003 with a focus on the recent 2009 surveys (Cook 2004, 2005, and 2006; Martini-Lamb et al. *In Press*).

Fish Distribution and Abundance

Fish captures from seine surveys in the Russian River Estuary from 2003 to 2009 are summarized in Table 4.4.1. During the 7-year study over 90,000 fish were caught in the Estuary consisting of 46 fish species. A total of 27,119 fish comprised of 32 species were recorded in 2009. In 2008 there were 14,360 fish caught comprising 24 species. Fish studies in the 1990s detected 18 to 28 species/year for a total of 49 species (Sonoma County Water Agency and Merritt Smith Consulting 2001). Our surveys from 2003 to 2009 found 21 fish species previously undetected during studies in the 1990s. During 2009 there were 6 new fish species detected in the Estuary, including kelp greenling (*Hexagrammos decagrammus*), Pacific sand sole (*Psettichthys melanostictus*), English sole (*Parophrys vetulus*), Pacific sanddab (*Citharichthys sordidus*), silverspotted sculpin (*Blepsias cirrhosus*), and mosquitofish (*Gambusia affinis*). All of these fish, except for the freshwater mosquitofish, are marine species.

The distribution of fish in the Estuary is, in part, based on a species preference for or tolerance to salinity (Figure 4.4.1). In general, the influence of cold seawater from the ocean results in high salinity levels and cool temperatures in the Lower Reach transitioning to warmer freshwater in the Upper Reach from river inflows (Figure 4.4.2). For more details please refer to the water quality section of this report. Fish commonly found in the Lower Reach were marine and estuarine species including topsmelt (*Atherinops affinis*), surf smelt (*Hypomesus pretiosus*), staghorn sculpin (*Leptocottus armatus*), and starry flounder (*Platichthys stellatus*). The Middle Reach had a broad range of salinities and a diversity of fish tolerant of these conditions. Common fish in the Middle Reach included those found in the Lower Reach and shiner surfperch (*Cymatogaster aggregata*), three-spine stickleback (*Gasterosteus aculeatus*), and prickly sculpin (*Cottus asper*). Freshwater dependent species, such as the Sacramento sucker (*Catostomus occidentalis*) and California roach (*Hesperoleucus symmetricus*), were predominantly distributed in the Upper Reach. Anadromous fish that can tolerate a broad range of salinities, such as steelhead (*Oncorhynchus mykiss*) and American shad (*Alosa sapidissima*), occurred throughout the Estuary.

Table 4.4.1: Total fish caught by beach seine in the Russian River Estuary from May to September, 2009. Each of the 8 sample stations were sampled 7 times during the study season.

					2009 Station Captures								
Family	**Common Name**	**Scientific Name**	**2003-07**	**2008**	**Mouth**	**Penny**	**Jenner**	**Patty**	**Willow**	**Sheep**	**Heron**	**Freeze**	**TOTAL**
Atherinidae	topsmelt	*Atherinops affinis*	X	X	54	144	10	71	93	45			417
Atherinidae	jacksmelt	*Atherinops californiensis*	X	X									0
Carangidae	jack mackerel	*Trachurus symmetricus*	X										0
Catostomidae	Sacramento sucker	*Catostomus occidentalis*	X	X	1			1	82	8	127	1332	1551
Centrarchidae	green sunfish	*Lepomis cyanellus*	X										0
Centrarchidae	bluegill	*Lepomis macrochirus*	X						3				3
Centrarchidae	largemouth bass	*Micropterus salmonoides*	X										0
Centrarchidae	black crappie	*Pomoxis nigromaculatus*	X										0
Clinidae	giant/striped kelpfish	*Heterostichus/ Gibbonsia sp*	X				1						1
Clupeidae	American shad	*Alosa sapidissima*	X	X	5	77	125	3	25	10	17	7	269
Clupeidae	Pacific herring	*Clupea harengus*	X	X	616	387	168	27					1198
Clupeidae	round herring	*Etrumeus teres*	X										0
Clupeidae	Pacific sardine	*Sardinops sagax caeruleus*	X										0
Cottidae	smoothhead sculpin	*Artedius lateralis*	X										0
Cottidae	silverspotted sculpin	*Blepsias cirrhosus*				1							1
Cottidae	prickly/coastrange sculpin	*Cottus asper/aleuticus*	X										0
Cottidae	prickly sculpin	*Cottus asper*	X	X	3	695	157	20	736	36	22	537	2206
Cottidae	buffalo sculpin	*Enophrys bison*	X										0

Family	Common Name	Scientific Name	2003-07	2008	2009 Station Captures								
					Mouth	Penny	Jenner	Patty	Willow	Sheep	Heron	Freeze	TOTAL
Cottidae	staghorn sculpin	*Leptocottus armatus*	X	X	37	549	114	47	491	9	14	13	1274
Cottidae	sharpnose sculpin	*Clinocottus acutieps*	X	X	7	7	2						16
Cottidae	tidepool sculpin	*Oligocottus maculosus*	X										0
Cottidae	cabezon	*Scorpaenichthys marmoratus*	X										0
Cottidae	rockfish (juveniles)	*Sebastes spp*	X	X	1	64	248	1	1				315
Cyprinidae	unidentified larvae	Cyprinid	X										0
Cyprinidae	Common Carp	*Cyprinus carpio*		X					30				30
Cyprinidae	California roach	*Hesperoleucus symmetricus*	X	X	1				1		11	36	49
Cyprinidae	hitch	*Lavinia exilicauda*	X	X								18	18
Cyprinidae	Sacramento blackfish	*Orthodon microlepidotus*	X										0
Cyprinidae	Sacramento pikeminnow	*Ptychocheilus grandis*	X	X						1	4	37	42
Embiotocidae	shiner surfperch	*Cymatogaster aggregata*	X	X	10	35		1	5127	296			5469
Embiotocidae	Russian River tuleperch	*Hysterocarpus traskii pomo*	X	X					47	1	5	393	446
Engraulididae	northern anchovy	*Engraulis mordax*	X										0
Gasterosteidae	threespine stickleback	*Gasterosteus aculeatus*	X	X	4	1392	126	87	4509	1080	657	2624	10479
Hexagrammidae	greenling (juv) species	*Hexagrammos sp*	X										0
Hexagrammidae	kelp greenling	*Hexagrammos decagrammus*					1						1
Hexagrammidae	lingcod	*Ophiodon elongatus*	X	X				1					1
Liparididae	snailfish species	*Liparis sp*	X										0
Osmeridae	surf smelt	*Hypomesus*	X	X	2224	78	159	8		7			2476

Family	Common Name	Scientific Name	2003-07	2008	2009 Station Captures								
					Mouth	Penny	Jenner	Patty	Willow	Sheep	Heron	Freeze	TOTAL
		pretiosus											
Paralichthyidae	Pacific sanddab	*Citharichthys sordidus*					2						2
Pholididae	penpoint gunnel	*Apodichthys flavidus*	X				2						2
Pholididae	saddleback gunnel	*Pholis ornata*	X	X		4	4	1	1				10
Pleuronectidae	starry flounder	*Platichthys stellatus*	X	X	4	27	15	12	25	3	19	208	313
Pleuronectidae	English sole	*Parophrys vetulus*			8	6	4	3					21
Pleuronectidae	Pacific sand sole	*Psettichthys melanostictus*			1								1
Poeciliidae	mosquitofish	*Gambusia affinis*							6				6
Salmonidae	coho salmon	*Oncorynchus kisutch*	X	X	12	2	2		3	13	1		33
Salmonidae	steelhead	*Oncorynchus mykiss*	X	X	1		7	10	6	43	3	24	94
Salmonidae	Chinook salmon	*Oncorynchus tshawytscha*	X	X	9	23	124	31	48	84	17	2	338
Syngnathidae	bay pipefish	*Syngnathus leptorhyncus (griseolineatus)*	X	X		19	1	4	7	1	5		37
	TOTAL		**42**	**24**	**2998**	**3510**	**1272**	**328**	**11241**	**1637**	**902**	**5231**	**27119**

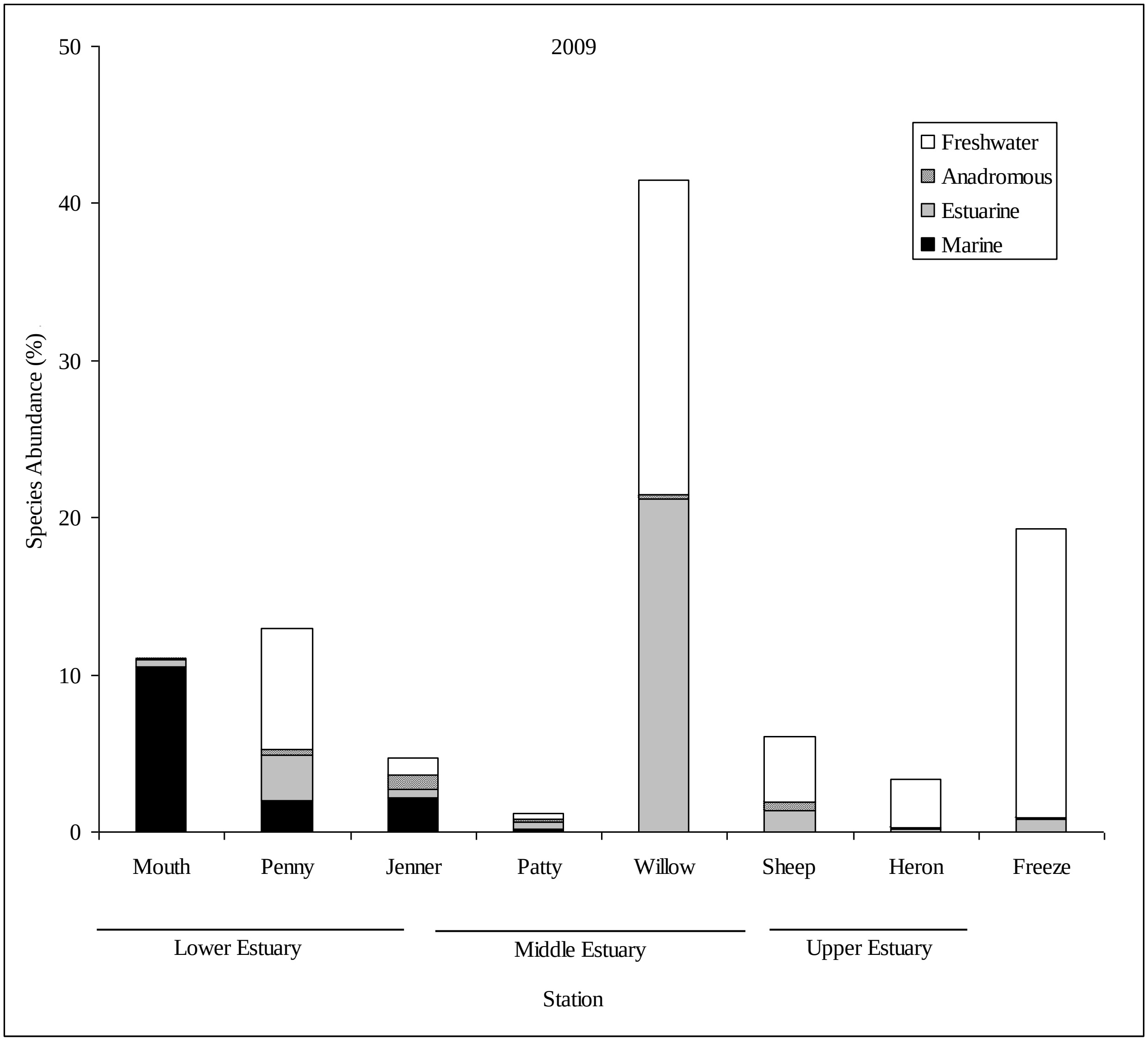

Figure 4.4.1. Distribution of fish in the Russian River Estuary based on salinity tolerance and life history, 2009. Groups include: freshwater resident species; species that are primarily anadromous; brackish-tolerant species that complete their lifecycle in estuaries; species that are predominantly marine residents.

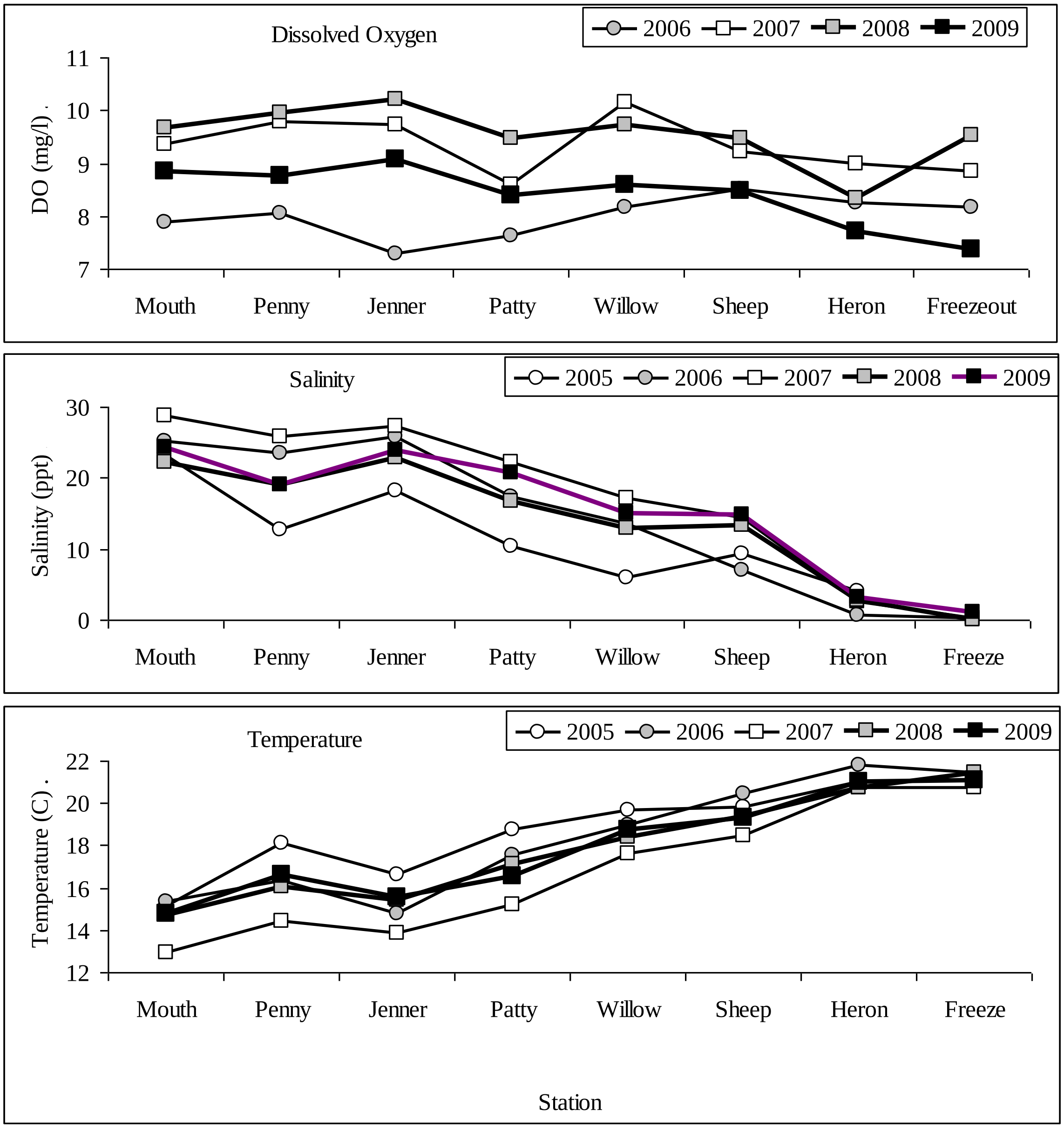

Figure 4.4.2. Water conditions at fish seining stations in the Russian River Estuary, 2005-2009. Values are averages collected at 0.5 m intervals in the water column from May through September.

Steelhead

There have been 699 parr and smolt steelhead captured by beach seine at the 8 stations in the Estuary from 2004 to 2009. During 2009, a total of 91 steelhead were captured (Table 4.4.1) in 168 seine sets resulting in a Catch Per Unit Effort (CPUE) of 0.54 fish/set, excluding October captures (Figure 4.4.3). Seventy-five of these steelhead were implanted with a PIT tag and two fish were later recaptured. All captured steelhead were wild, except one hatchery steelhead caught at Jenner Gulch station during 2005. The number and size of steelhead are shown in Table 4.4.2.

The seasonal abundance of steelhead captured varied annually, but was usually highest in May and decreased throughout the summer (Figure 4.4.4). During 2009, the frequency of steelhead captures was highest during May (1.0 fish/set) and lowest in September (0.2 fish/set).

Over the past 6 years of sampling, we have found steelhead patchily distributed in the Estuary (Figure 4.4.5). During 2005, juvenile steelhead were caught throughout most of the Estuary, while in 2004 and 2006, steelhead were only found in the Middle Reach at the Patty Rock, Willow Creek, and Sheephouse Creek stations. Since sampling began at the Freezeout Bar station in 2006, we have encountered steelhead frequently at this upper estuary site. Steelhead were rarely captured at the two lower stations (River Mouth and Penney Island) during all survey years. In 2009, Sheephouse Creek station had the highest CPUE of steelhead at 1.9 fish/set.

The temporal distribution of steelhead in the Estuary varied greatly and our results were strongly influenced by large captures in the Upper Estuary reach early in the survey season (Figure 4.4.6). Most age 0+ steelhead were found in the Upper and Middle reaches of the Estuary during May and June. Few steelhead were found in the Lower Reach early in the season. Conversely, from July to September most steelhead were found in the Middle and Lower reaches.

Table 4.4.2. Sizes of juvenile steelhead in the Russian River Estuary, 2004-2009. Fish caught during beach seining at 8 survey stations.

		Steelhead Fork Length (mm)			
Year	N	Mean	Standard Deviation	Minimum	Maximum
2004	55	113.4	55.3	55	320
2005	138	111.6	48.4	43	275
2006	12	90.6	43.5	50	198
2007	106	133.4	49.5	45	255
2008	286	121.4	49.5	46	276
2009	91	121.0	55.5	48	296

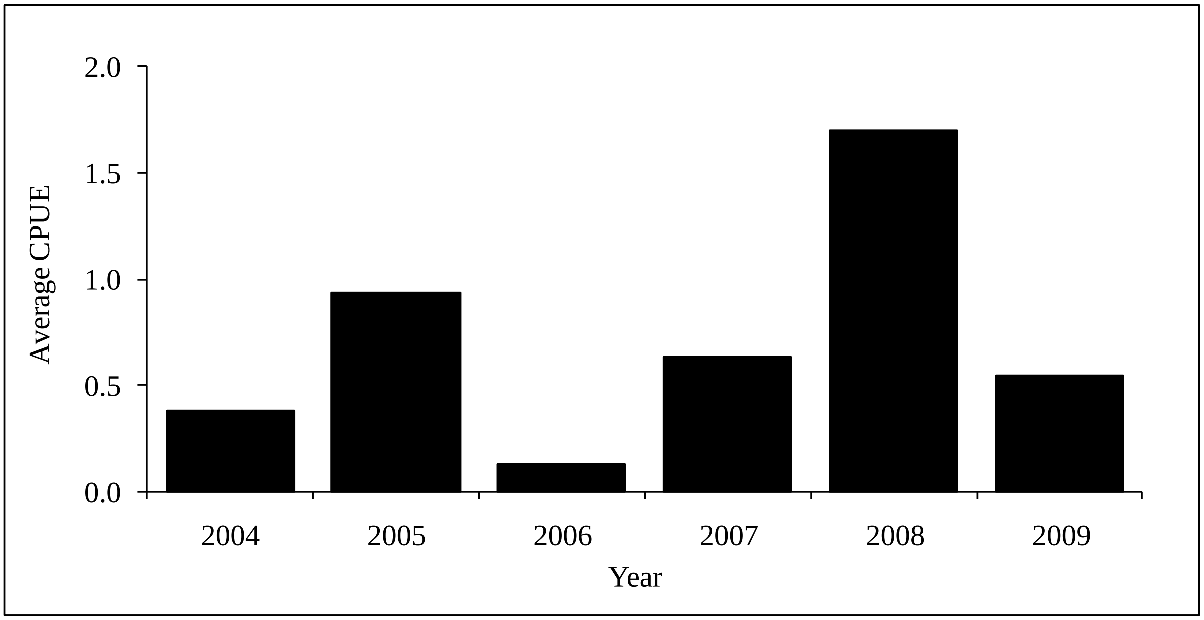

Figure 4.4.3. Relative abundance of juvenile steelhead captured by beach seine in the Russian River Estuary. Samples are capture per unit effort (CPUE) from 3 seine sets at each station during May to September surveys. Sampling at Freezeout Bar station began in 2006.

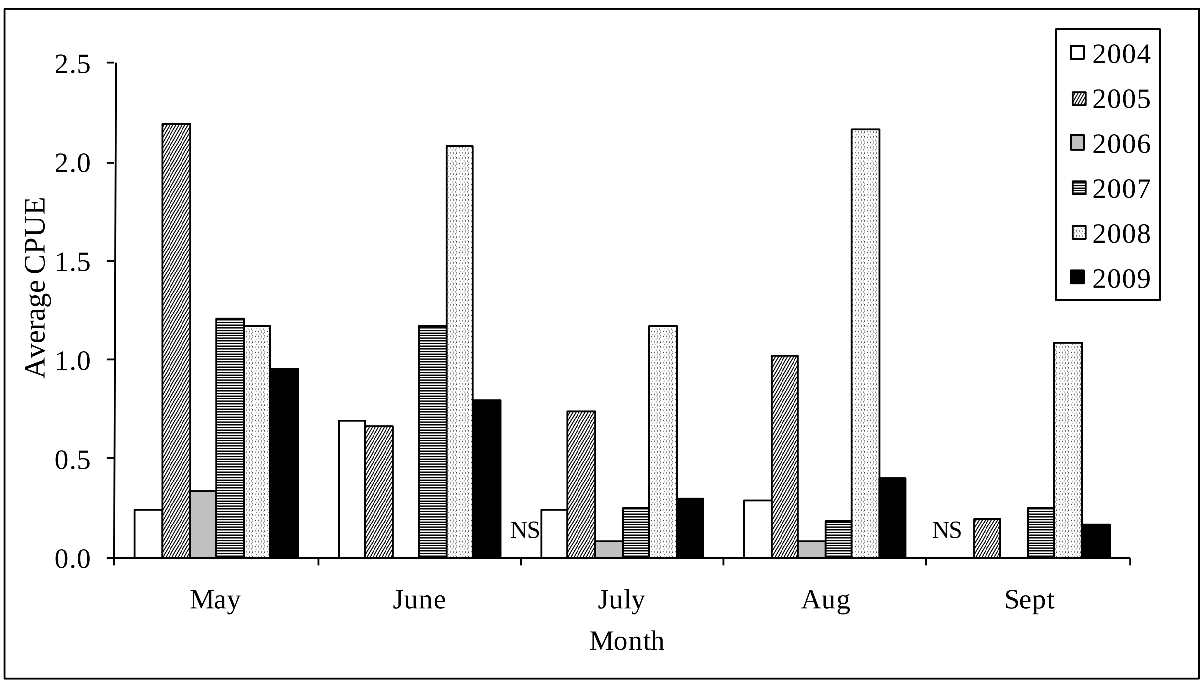

Figure 4.4.4. Seasonal abundance (CPUE) of juvenile steelhead captured by beach seine in the Russian River Estuary. Sampling at Freezeout Bar station began in 2006. No surveys (NS) were conducted during September 2004 and June 2006.

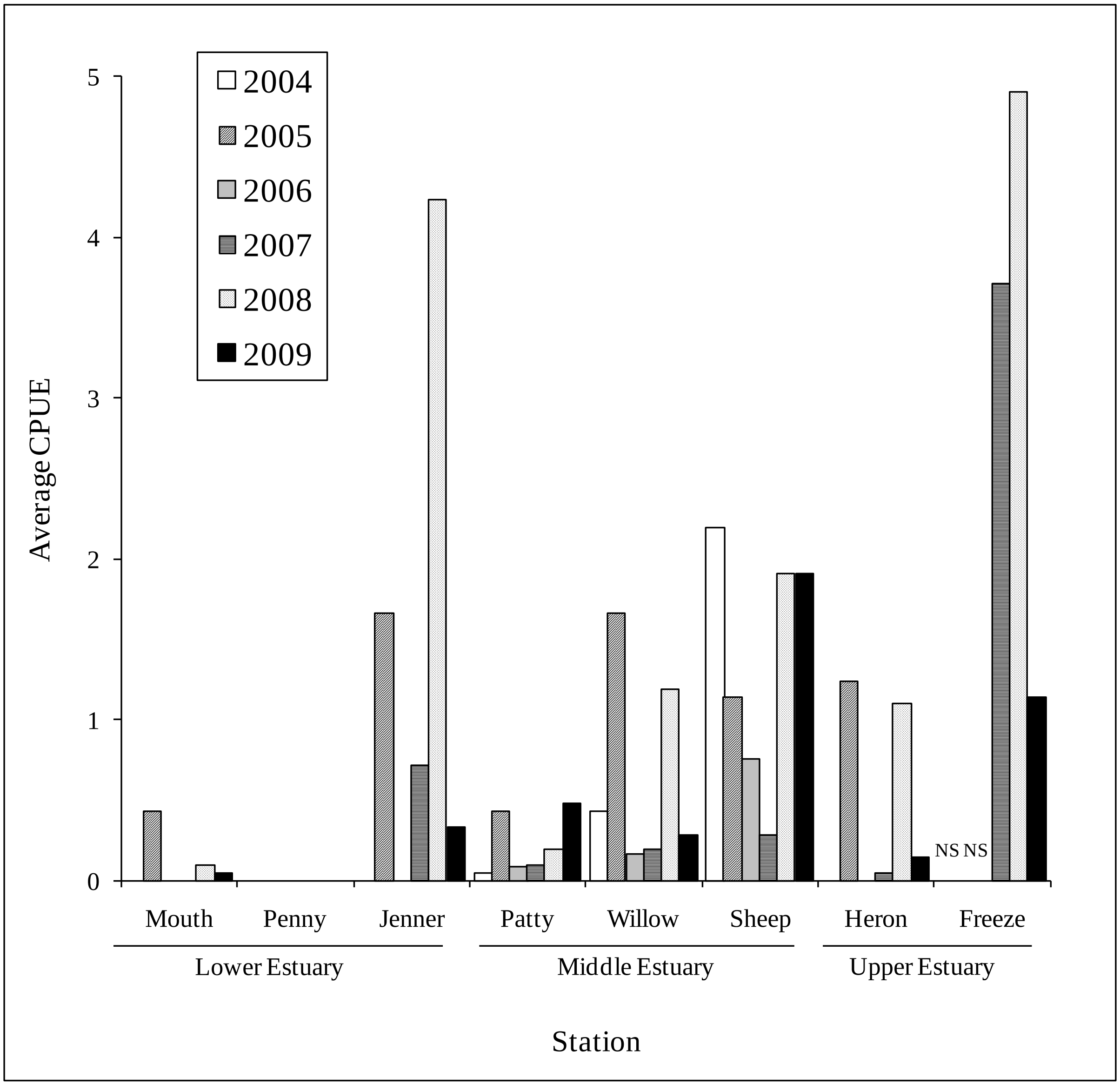

Figure 4.4.5. Average CPUE of juvenile steelhead at 8 seining stations in the Russian River Estuary between May and September 2004 to 2009. No surveys (NS) were conducted at Freezeout Bar station in 2004 and 2005.

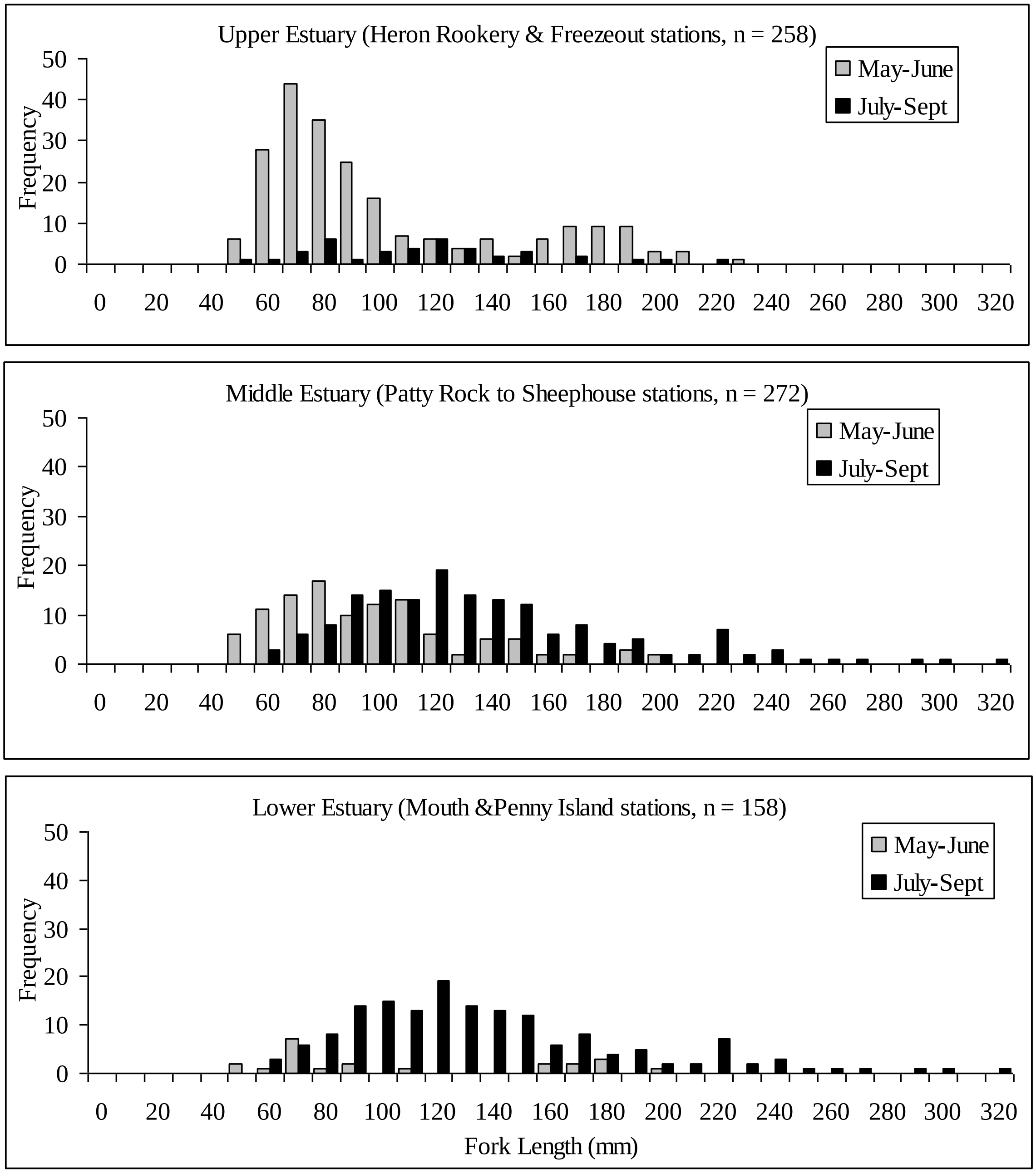

Figure 4.4.6: Length frequency of juvenile steelhead in reaches of the Russian River Estuary, 2004-2009. Fish captures are grouped by Estuary reach and season. Samples are from beach seining surveys.

Chinook Salmon

Relative abundance of Chinook smolts in 2009 was half that observed the previous year consisting of 337 total fish for an average CPUE of 2.0 fish/set (Figure 4.4.7). Over the past 6 years, CPUE was lowest in 2005 (0.7 fish/set) and highest in 2008 (4.6 fish/set). Chinook salmon smolts were usually most abundant during May or June and rarely encountered by July (Figure 4.4.8). Although a similar temporal pattern was observed during 2007 to 2009 as in past seasons, a few smolts were captured later in the season into September. Chinook salmon smolts were distributed throughout the Estuary with captures at most sample stations annually (Figure 4.4.9). CPUE was highest in 2009 at the Jenner Gulch station (5.9 fish/set). In 2008, the highest CPUE occurred at Willow Creek (16.9 fish/set).

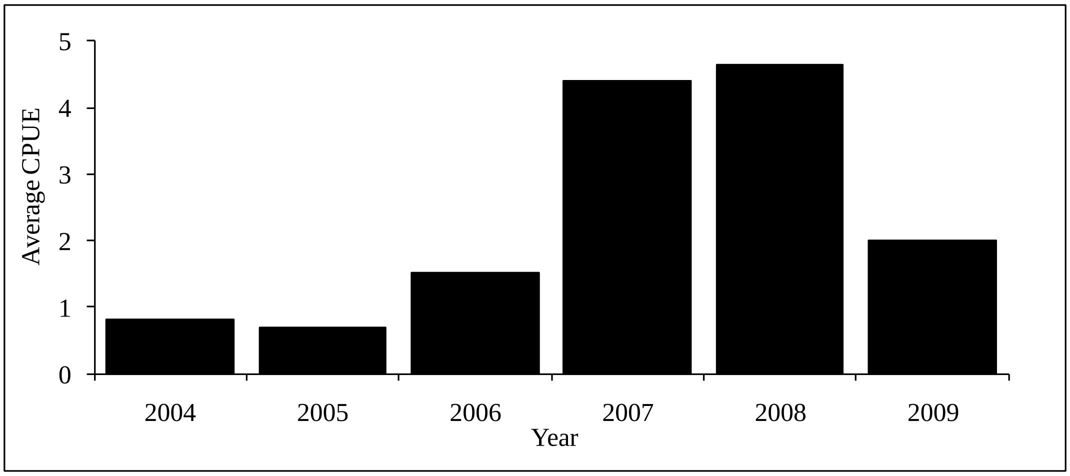

Figure 4.4.7. Average annual CPUE of Chinook salmon smolts captured by beach seine at 8 sites in the Russian River Estuary between May and September 2004 to 2009.

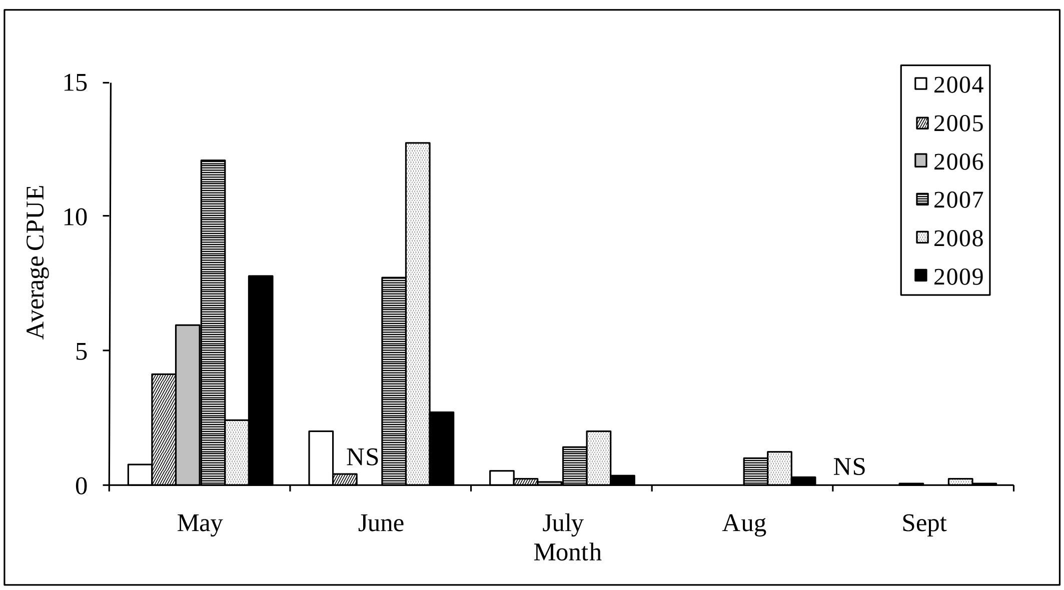

Figure 4.4.8. Monthly CPUE of Chinook salmon smolts captured by beach seine at 8 sites in the Russian River Estuary between May and September 2004 to 2009. No surveys (NS) were conducted during September 2004 and June 2006.

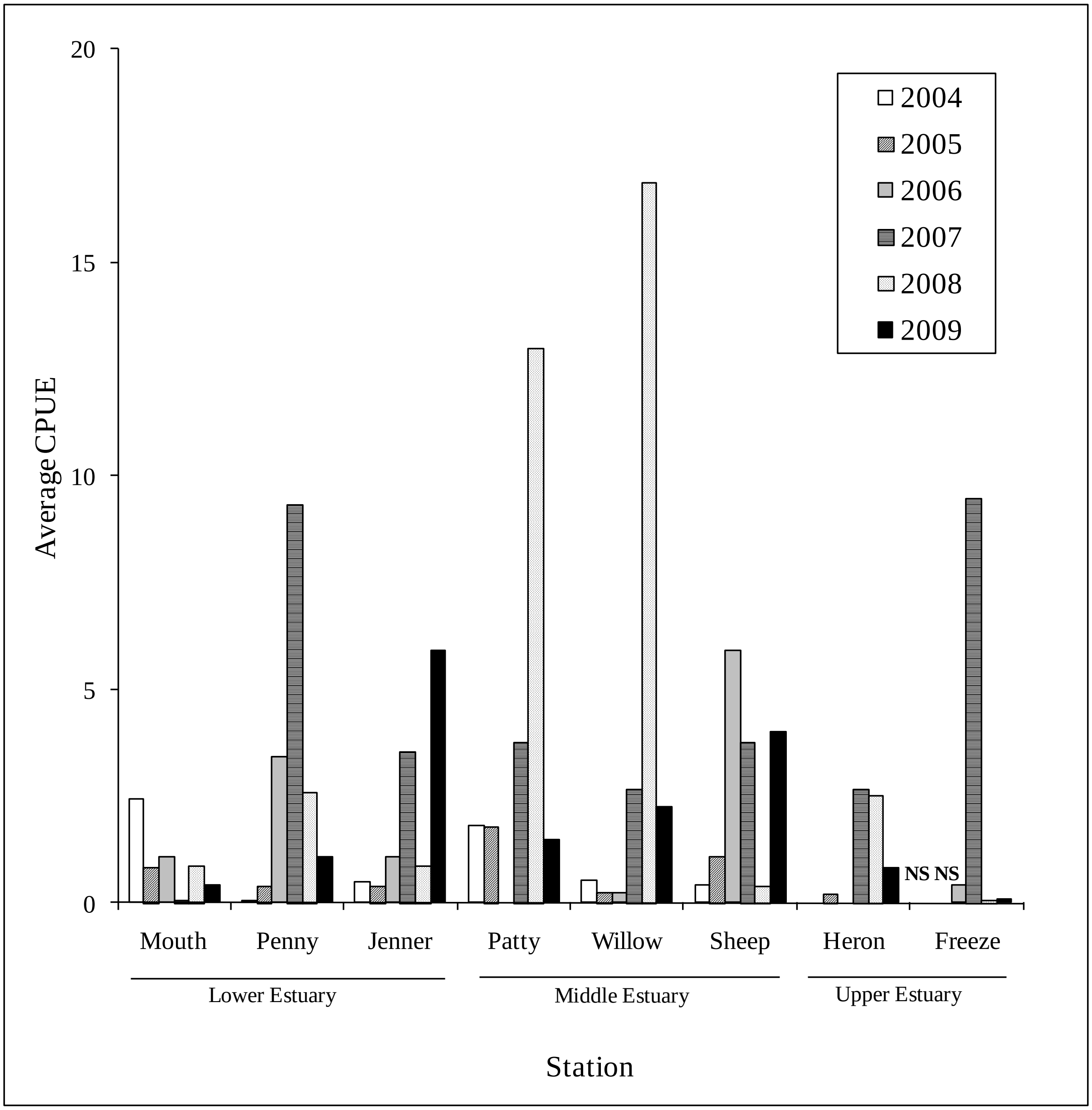

Figure 4.4.9. Average CPUE of Chinook salmon smolts at 8 seining stations in the Russian River Estuary between May and September 2004 to 2009. No surveys (NS) were conducted at Freezeout Bar station in 2004 and 2005.

Coho Salmon

Very few coho salmon smolts have been captured in the Estuary during our beach seining surveys. A total of 77 smolts have been captured since 2004. Most of these captures were in 2007 (34 fish) and 2009 (33 fish) (Table 4.4.1; Figure 4.4.10). Low coho captures in the Estuary are related to their low numbers in the Russian River watershed, but also the timing of our seining surveys that begin in late-May or June when most smolts have already migrated to the ocean. Most coho smolts in 2007 were caught at Freezeout Bar station, while during 2009 most coho were found at the River Mouth and Sheephouse Creek stations (Figures 4.4.11). Nearly all smolts were captured during May or early June (Figure 4.4.12). Most smolts had a clipped adipose fin indicating they originated from the Coho Salmon Captive Broodstock Hatchery Program. One wild smolt was caught on October 3, 2005 at the River Mouth station (not shown on Figure 4.4.12) and one wild smolt was captured on May 21, 2009 at the River Mouth Station.

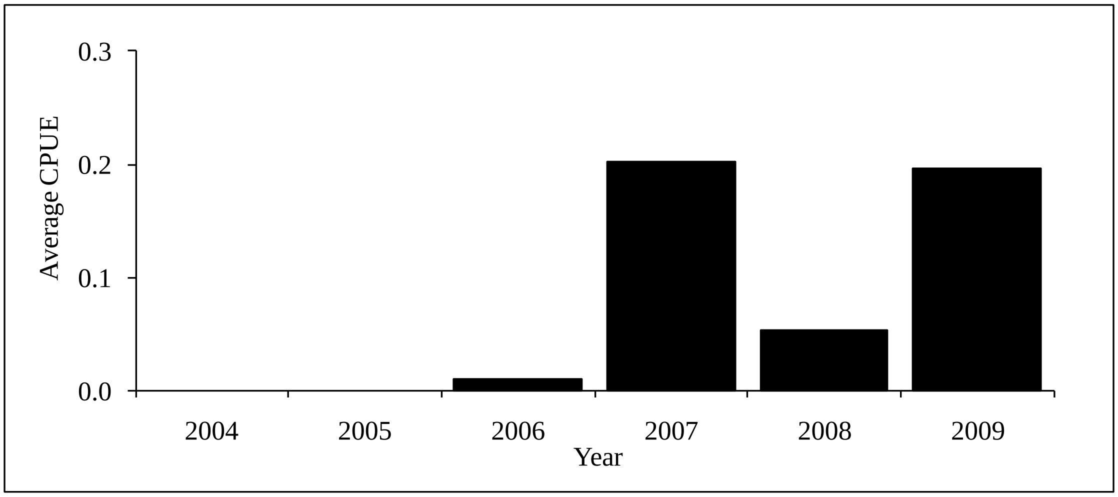

Figure 4.4.10. Average CPUE of coho salmon smolts at 8 seining stations in the Russian River Estuary between May and September 2004 to 2009.

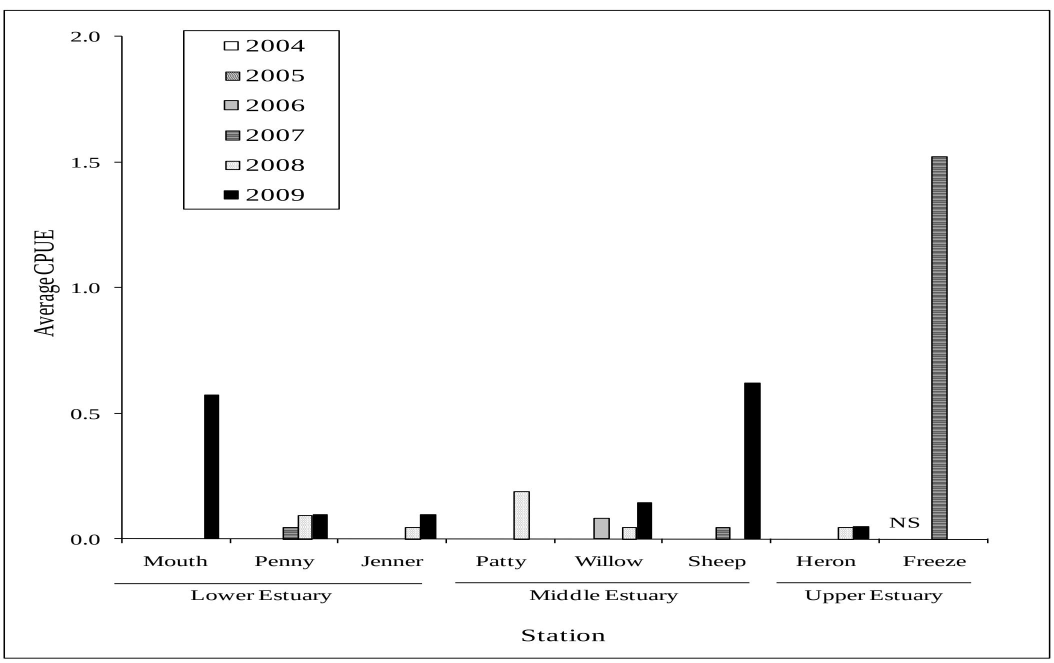

Figure 4.4.11. Average annual CPUE of coho salmon smolts captured by beach seine at 8 sites in the Russian River Estuary between May and September 2004 to 2009. No surveys (NS) were conducted at Freezeout Bar station in 2004 and 2005.

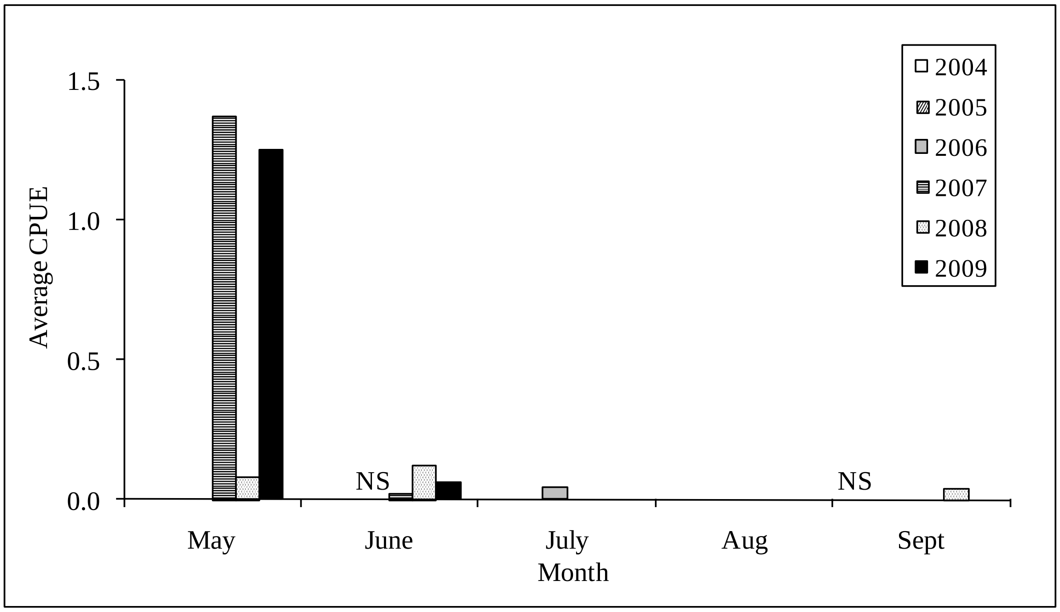

Figure 4.4.12. Seasonal abundance (CPUE) of juvenile steelhead captured by beach seine in the Russian River Estuary. Sampling at Freezeout Bar station began in 2006. No surveys (NS) were conducted during September 2004 and June 2006.

American Shad

American shad is an anadromous sportfish, native to the Atlantic coast. It was introduced to the Sacramento River in 1871, and within two decades, was abundant locally and had established populations from Alaska to Mexico (Moyle 2002). Adults spend from 3 to 5 years in the ocean before migrating upstream to spawn in the main channels of rivers. Juveniles spend the first year or two rearing in rivers or estuaries.

The annual CPUE of American shad in the Estuary has ranged from 0.3 fish/set in 2005 to 23.3 fish/set in 2006 (Figure 4.4.13). The high capture rate in 2006 is largely from a single seine set at the Sheephouse Creek station when 1,540 juveniles were netted on August 14, 2006. During 2009, the shad CPUE was 1.4 fish/set. The distribution of juvenile American shad followed a recurring seasonal pattern. They first appeared in relatively large numbers in July and the catch usually peaked in August, although during 2009 season the largest captures were in June (Figure 4.4.14). Young-of-the-year (age 0+) shad were primarily captured at the Sheephouse Creek station or in the Upper Reach, except during 2008 and 2009 when most shad were captured in the Lower Estuary.

Topsmelt

Topsmelt are one of the most abundant fish in California estuaries (Baxter et al. 1999) and can tolerate a broad range of salinities and temperatures, but are seldom found in freshwater (Moyle 2002). They form schools and are often found near the water surface in shallow water. Sexual maturity is reached in 1 to 3 years and individuals can live as long as

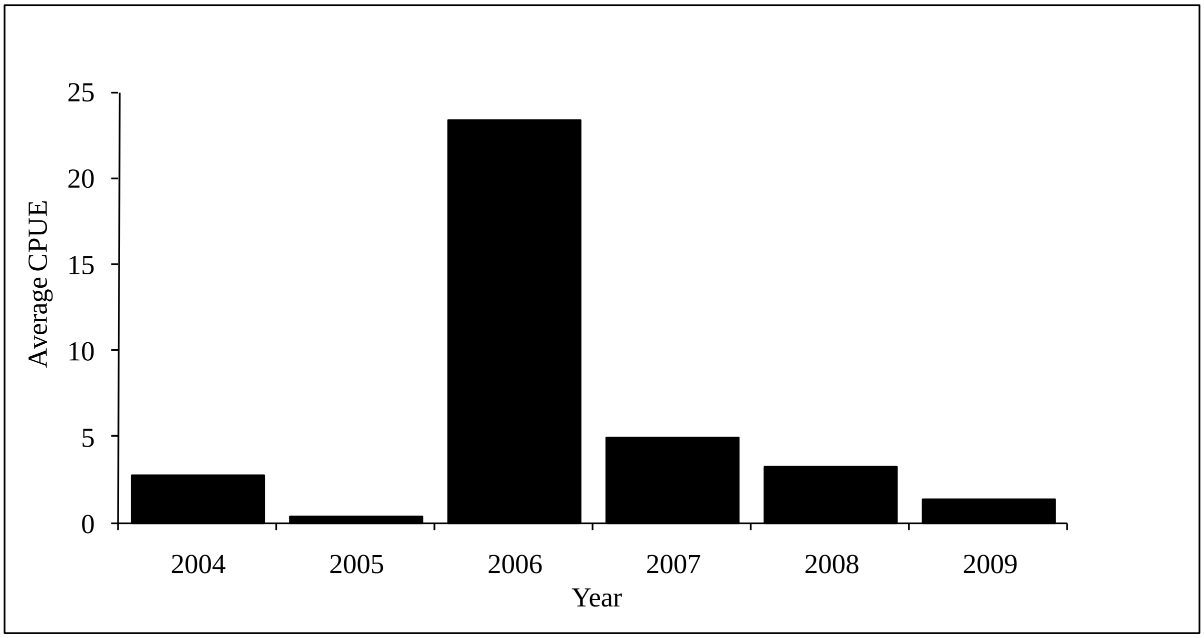

Figure 4.4.13. Average CPUE of American shad (age 0+) captured by beach seine in the Russian River Estuary. Samples are from 3 seine pulls at each station during May to September surveys. Sampling at Freezeout Bar station began in 2006.

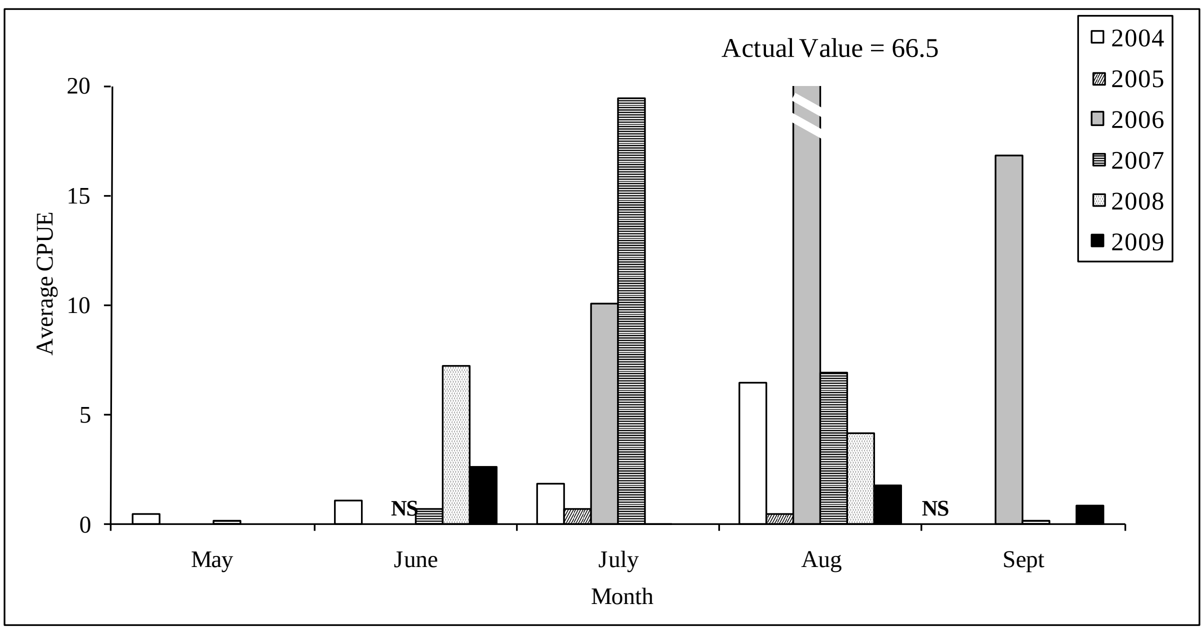

Figure 4.4.14. Seasonal abundance (CPUE) of American shad (age 0+) captured by beach seine in the Russian River Estuary. Samples are from 3 seine pulls at each station during May to September surveys. Sampling at Freezeout Bar station began in 2006. No surveys (NS) were conducted during September 2004 and June 2006.

7 to 8 years. Estuaries are used as nursery and spawning grounds and adults spawn in late-spring to summer.

The abundance of topsmelt in the Estuary was lower in 2009 than previous years (Figure 4.4.15). The seasonal distribution of topsmelt included low numbers during May and June followed by increased numbers in July and August (Figure 4.4.16). The peak seasonal abundance was during September 2007 with a CPUE of 28.0 fish/set. Topsmelt were restricted to the Lower and Middle reaches where brackish water conditions are common, and were seldom captured upstream of Sheephouse Creek station where tidal influences are low. The highest occurrence of topsmelt was at Patty Rock and Willow Creek stations in 2006 with CPUE of 28.3 and 37.1 fish/set, respectively. During 2009, the highest capture rate was 3.3 fish/set at Willow Creek station.

Starry Flounder

Starry flounder range from Japan and Alaska to Santa Barbara in coastal marine and estuarine environments. In California, they are common in bays and estuaries (Moyle 2002). This flatfish is usually found dwelling on muddy or sandy bottoms. Males mature during their second year and females mature at age 3 or 4 (Baxter et al. 1999). Spawning occurs during winter along the coast, often near the mouths of estuaries. Young flounders spend at least their first year rearing in estuaries. They move into estuaries during the spring and generally prefer warm, low-salinity water or freshwater. As young grow, they shift to using brackish waters.

The CPUE of starry flounder in the Russian River Estuary has generally declined since 2004, although there was a slight increase in 2009 (Figure 4.4.17). Seasonal changes in river outflow in combination with changing ocean conditions likely affect the strength of year classes (Baxter et al. 1999). The Estuary appears to be utilized primarily by young-of-the-year fish and 94% of the flounder catch in 2009 was less than 100 mm fork length. The seasonal distribution of starry flounder was typically highest in May and June, and then gradually decreased through September when few were caught (Figure 4.4.18). Starry flounder were distributed throughout the Estuary ranging from the River Mouth station, with cool seawater conditions, to Freezeout Bar station, with warm freshwater. Starry flounder have been detected as far upstream as Austin Creek (Cook 2006).

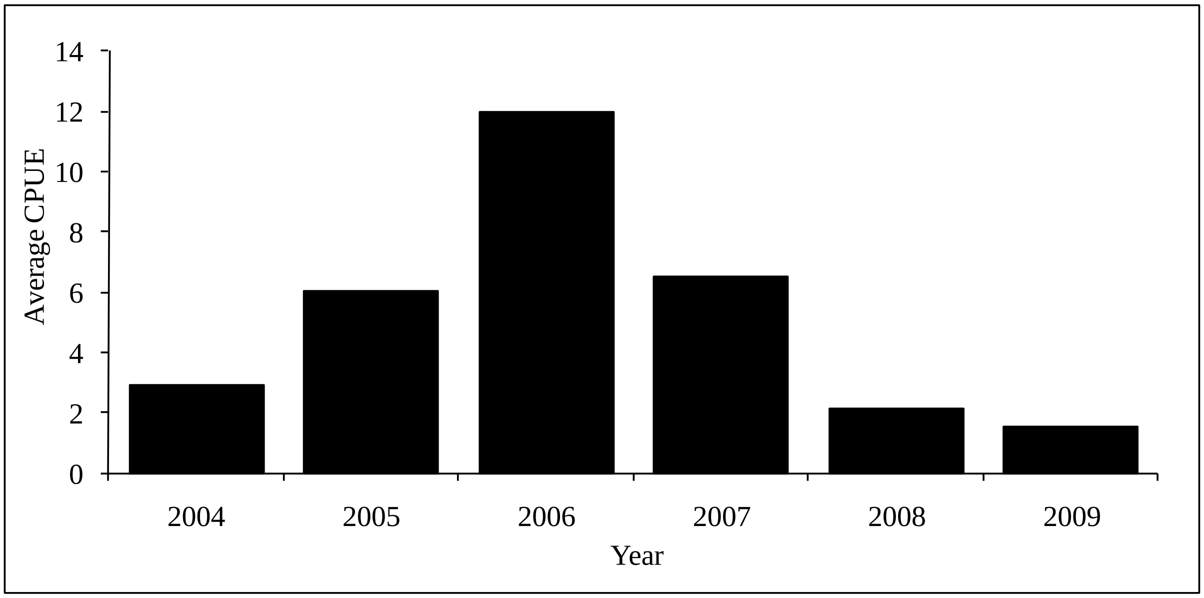

Figure 4.4.15 Average CPUE of topsmelt in the Russian River Estuary. Samples are from 3 seine pulls at each station during May to September surveys. Sampling at Freezeout Bar station began in 2006.

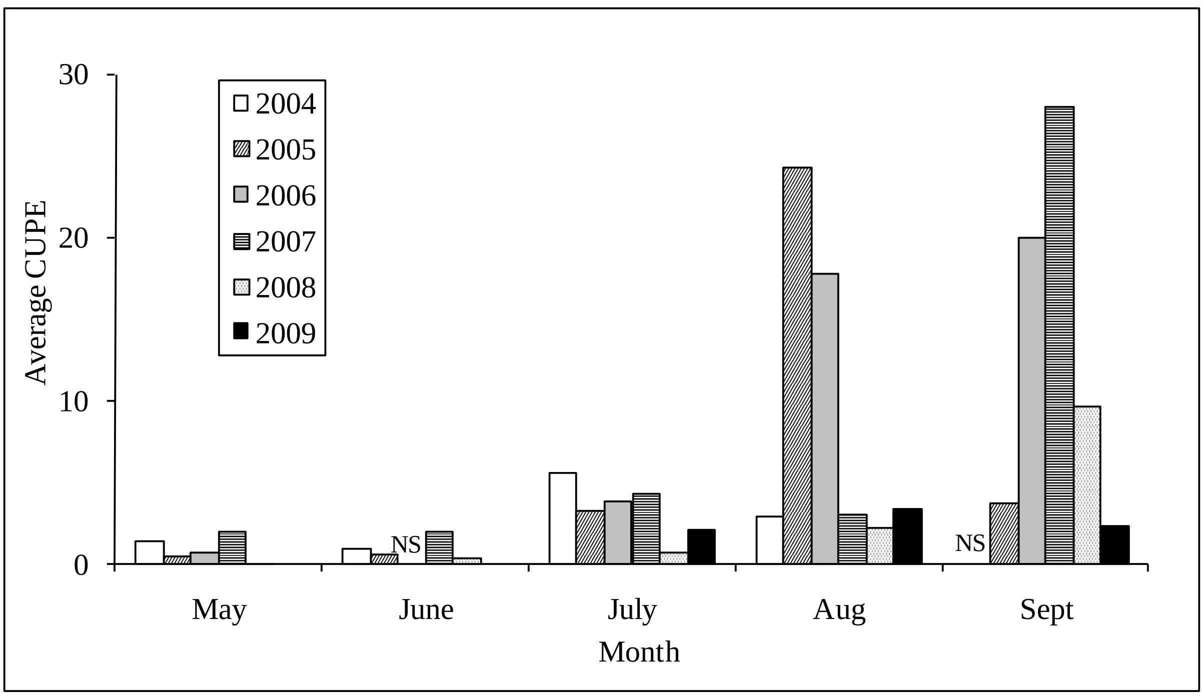

Figure 4.4.16. Seasonal abundance (CPUE) of topsmelt in the Russian River Estuary. Samples are from 3 seine pulls at each station during May to September surveys. Sampling at Freezeout Bar station began in 2006. No surveys (NS) were conducted during September 2004 and June 2006.

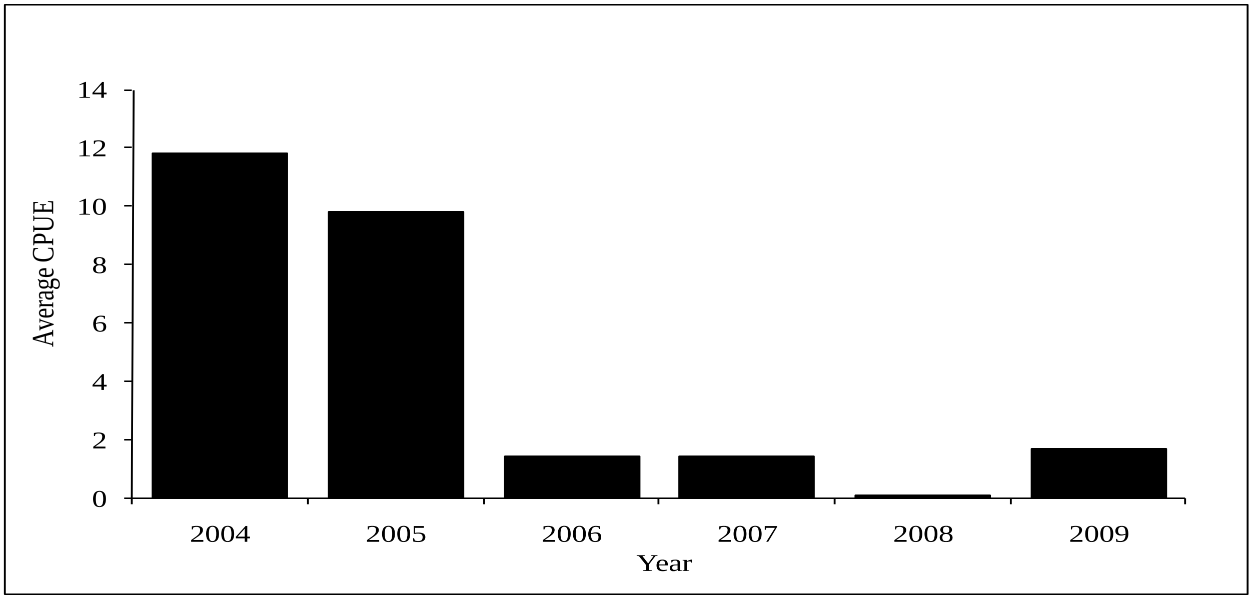

Figure 4.4.17 Average CPUE of starry flounder in the Russian River Estuary. Samples are from 3 seine pulls at each station during May to September surveys. Sampling at Freezeout Bar station began in 2006.

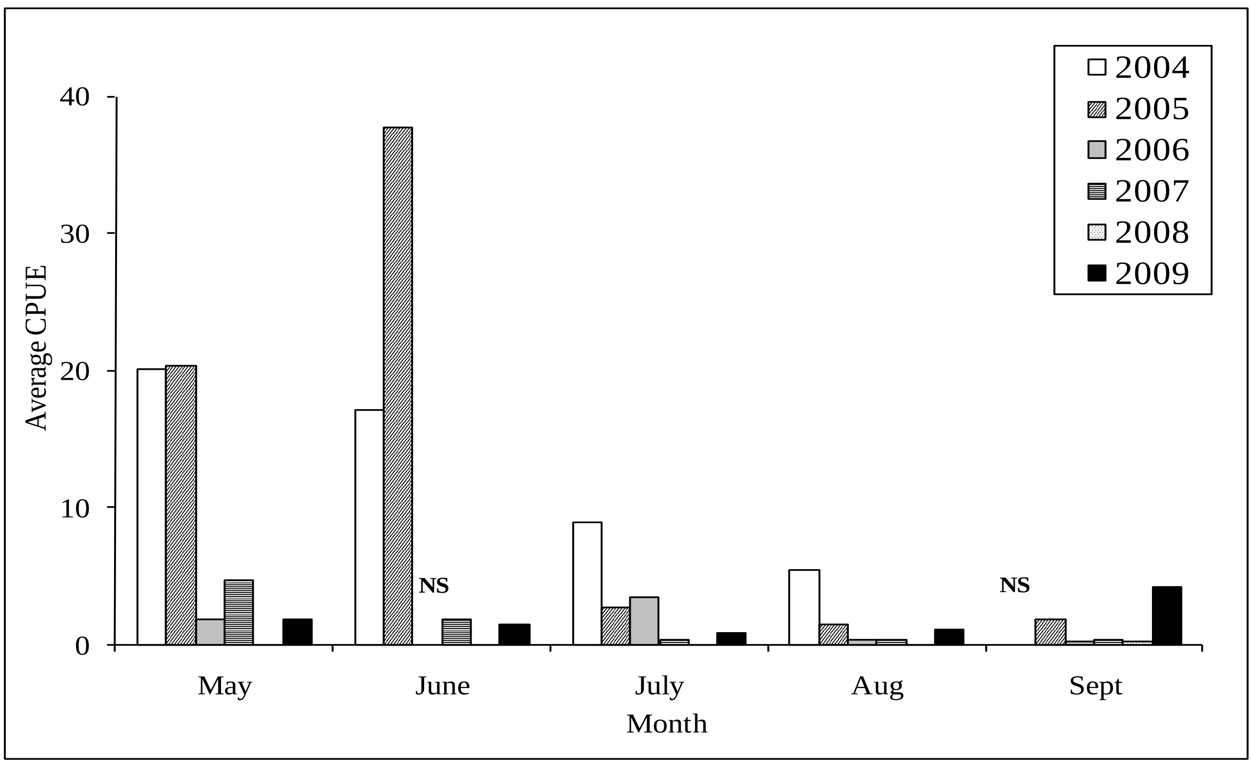

Figure 4.4.18. Seasonal abundance (CPUE) of starry flounder in the Russian River Estuary. Samples are from 3 seine pulls at each station during May to September surveys. Sampling at Freezeout Bar station began in 2006. No surveys (NS) were conducted during September 2004 and June 2006.

Fish Response to Estuary Closure

A river mouth closure lasting 29 days occurred from September 6 through October 5, 2009 (please see water quality section of this report for more detail). This prolonged freshening of the Estuary provided an opportunity to compare the response of fish to changes in water quality conditions. The below summary includes standardized fish surveys conducted before the mouth closed (August 31-September 2), during the mouth closure (September 21-23), and after the mouth reopened (October 12 and 20-21).

To augment water quality data collected by continuously recording data sondes (see water quality section of this report), we manually collected salinity, temperature, and DO vertical profiles when we seined each site. Figures 4.4.19, 4.4.20, and 4.4.21 show water quality conditions during closed-mouth conditions at three fish seining stations located in the Lower, Middle, and Upper Estuary. In general, during the prolonged mouth closure there were three strata observed in the water column. These strata consisted of a surface layer of warm fresh (or slightly brackish) water to a depth of about 1.5 m, a mid-depth layer approximately 3-m-thick with warmer temperatures, increased salinity, and increased dissolved oxygen, and a bottom layer of colder seawater with low dissolved oxygen sometimes approaching anoxia.

Overall, there was a shift in the fish composition in the Estuary during the mouth closure and then a re-distribution of species after the mouth reopened (Figure 4.4.22). During open-mouth conditions marine and estuarine fish species were found throughout the Lower and Middle Estuary. When the mouth closed, captures of marine fish were concentrated near the river mouth where the highest salinities occurred. Species most tolerant of brackish estuarine conditions, such of starry flounder and bay pipefish, expanded their distribution and were found as far upstream as Freezeout Bar. This upstream movement of estuarine fish can be explained by the upstream migration of the seawater wedge due to closed-mouth conditions. During fish surveys at Freezeout Bar station under closed-mouth conditions salinity levels were as high as 10.9 ppt (Figure 4.4.20). After the river mouth reopened there were fewer marine fish detected anywhere in the Estuary and estuarine fish were redistributed in the Lower and Middle Estuary.

Topsmelt is an estuarine fish that is most common in the middle reach of the Estuary where brackish waters are prevalent. Before the mouth closure topsmelt occurred in large numbers from Penny Island to Sheephouse Creek (Figure 4.4.23). During the mouth closure topsmelt were restricted to a smaller area of the Estuary, mostly in the Lower Estuary. After the mouth reopened to tidal action topsmelt were once again found at all seining stations detected prior to the closure.

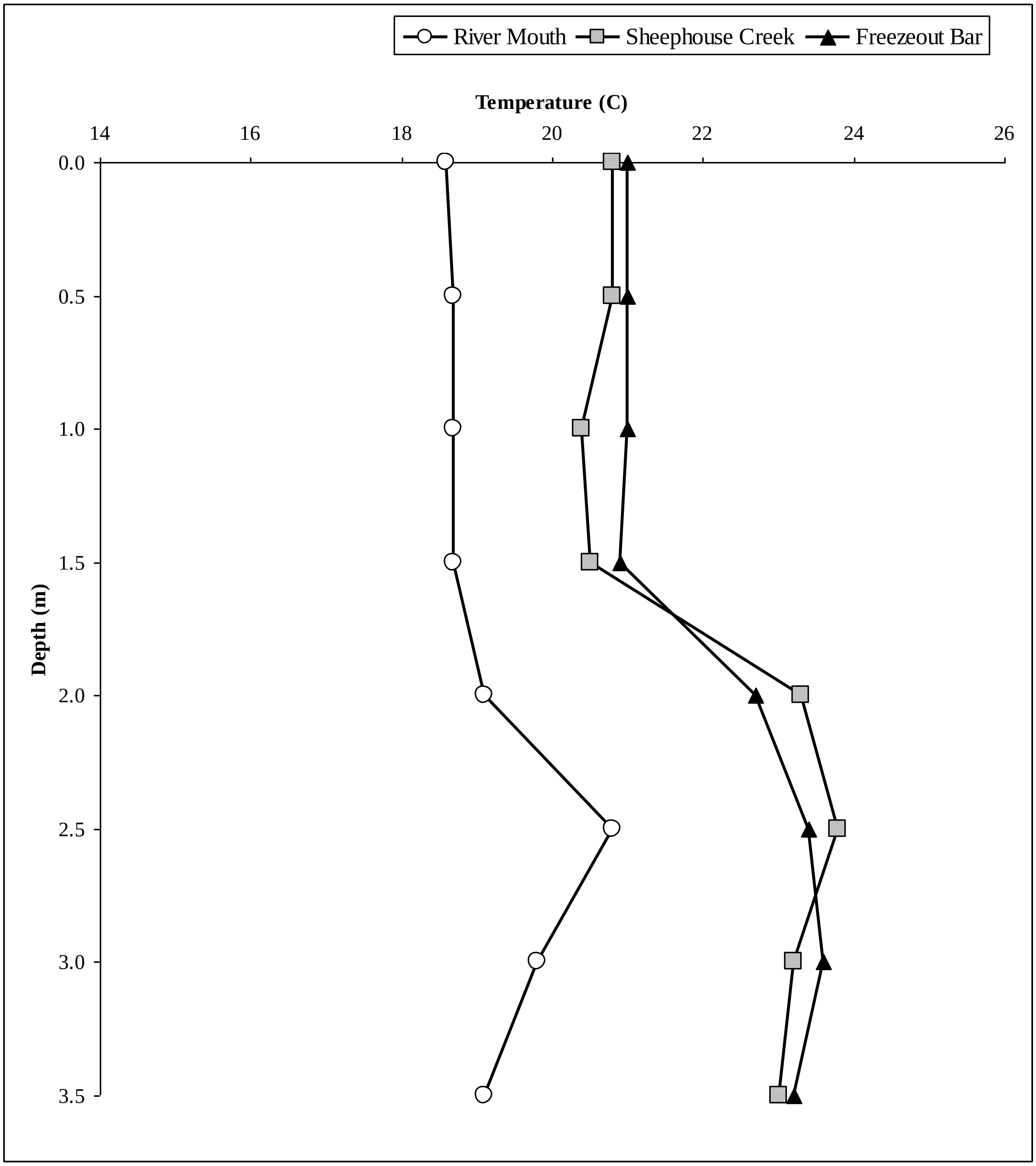

Figure 4.4.19: Temperature at three fish sampling stations during closed-mouth conditions, Russian River Estuary, September 21-23, 2009. Water quality data was collected at 0.5 m intervals to a depth of 3.5 m.

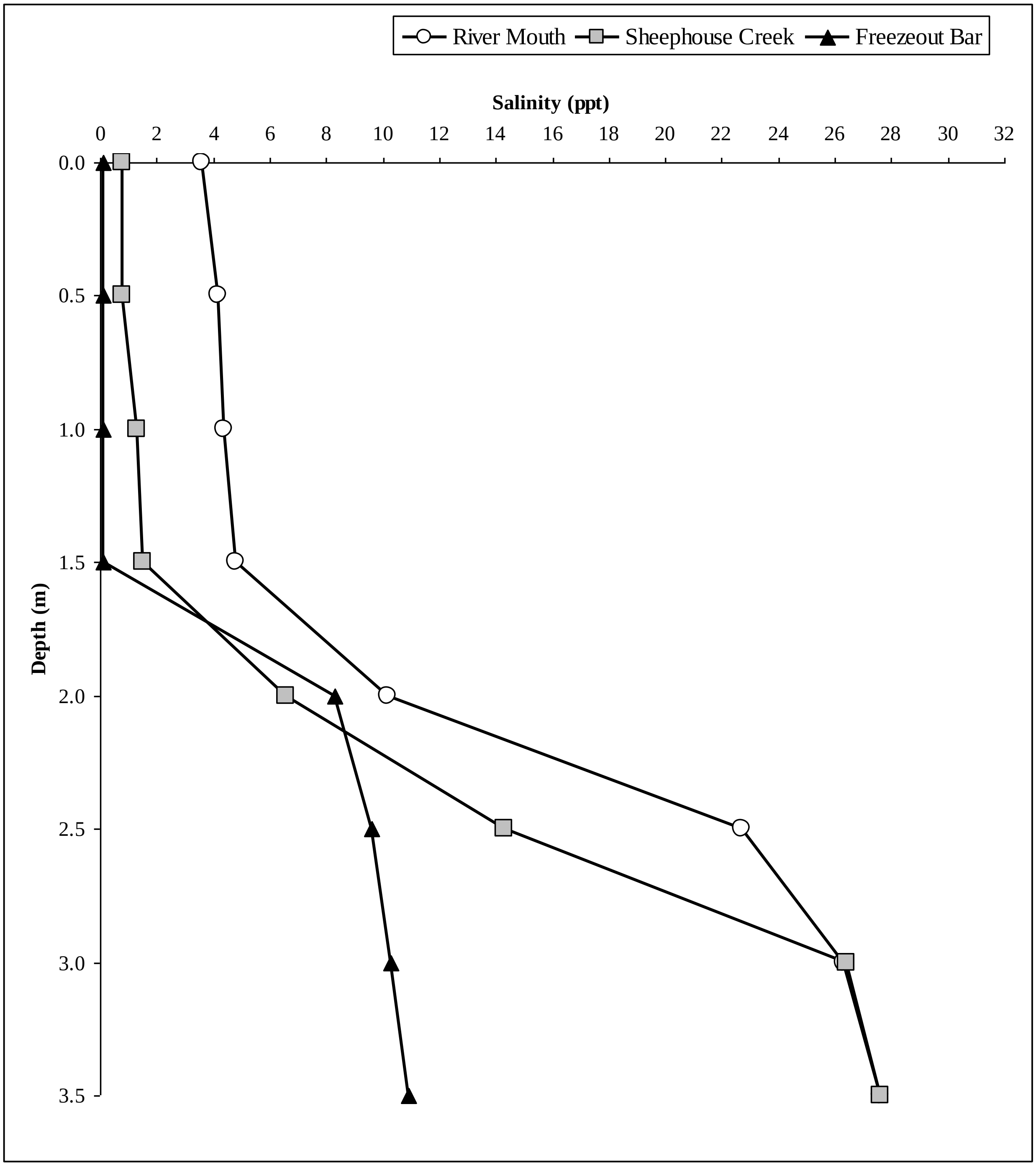

Figure 4.4.20: Salinity at three fish sampling stations during closed-mouth conditions, Russian River Estuary, September 21-23, 2009. Water quality data was collected at 0.5 m intervals to a depth of 3.5 m.

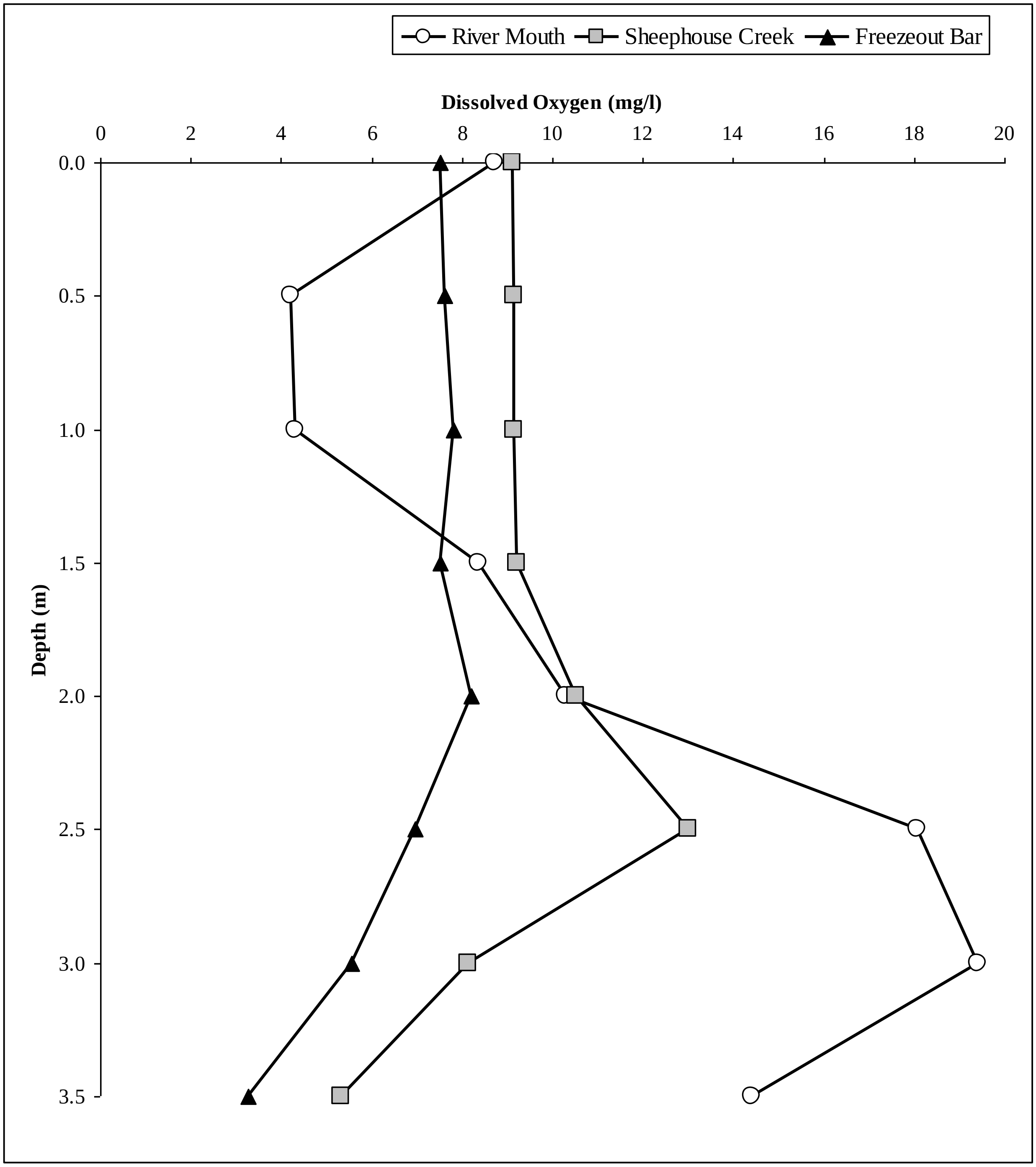

Figure 4.4.21: Dissolved oxygen at three fish sampling stations during closed-mouth conditions, Russian River Estuary, September 21-23, 2009. Water quality data was collected at 0.5 m intervals to a depth of 3.5 m.

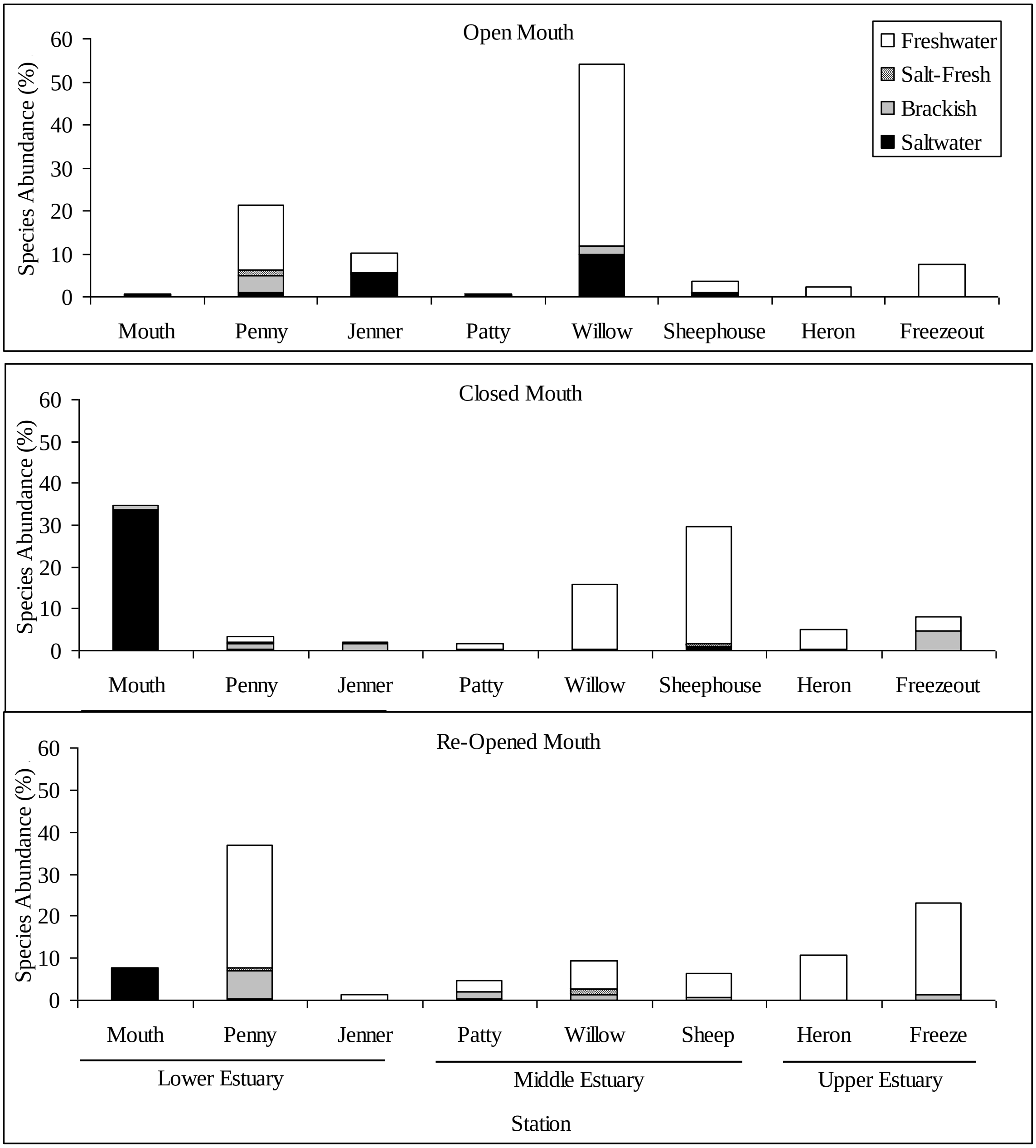

Figure 4.4.22: Distribution of fish species in the Russian River Estuary based on tolerance to salinity during open, closed, and re-opened mouth conditions. The river mouth closed for 29 days from September 6 to October 5, 2009. Surveys were conducted during August 31-September 2 (open), September 21- 23 (closed), and October 12, 21-22 (re-opened). Data is from eight beach seining stations. Groups include: Freshwater species intolerant of salinity; Salt-Fresh species that are primarily anadromous; Brackish species that complete their lifecycle in estuaries; Saltwater species that are predominantly marine.

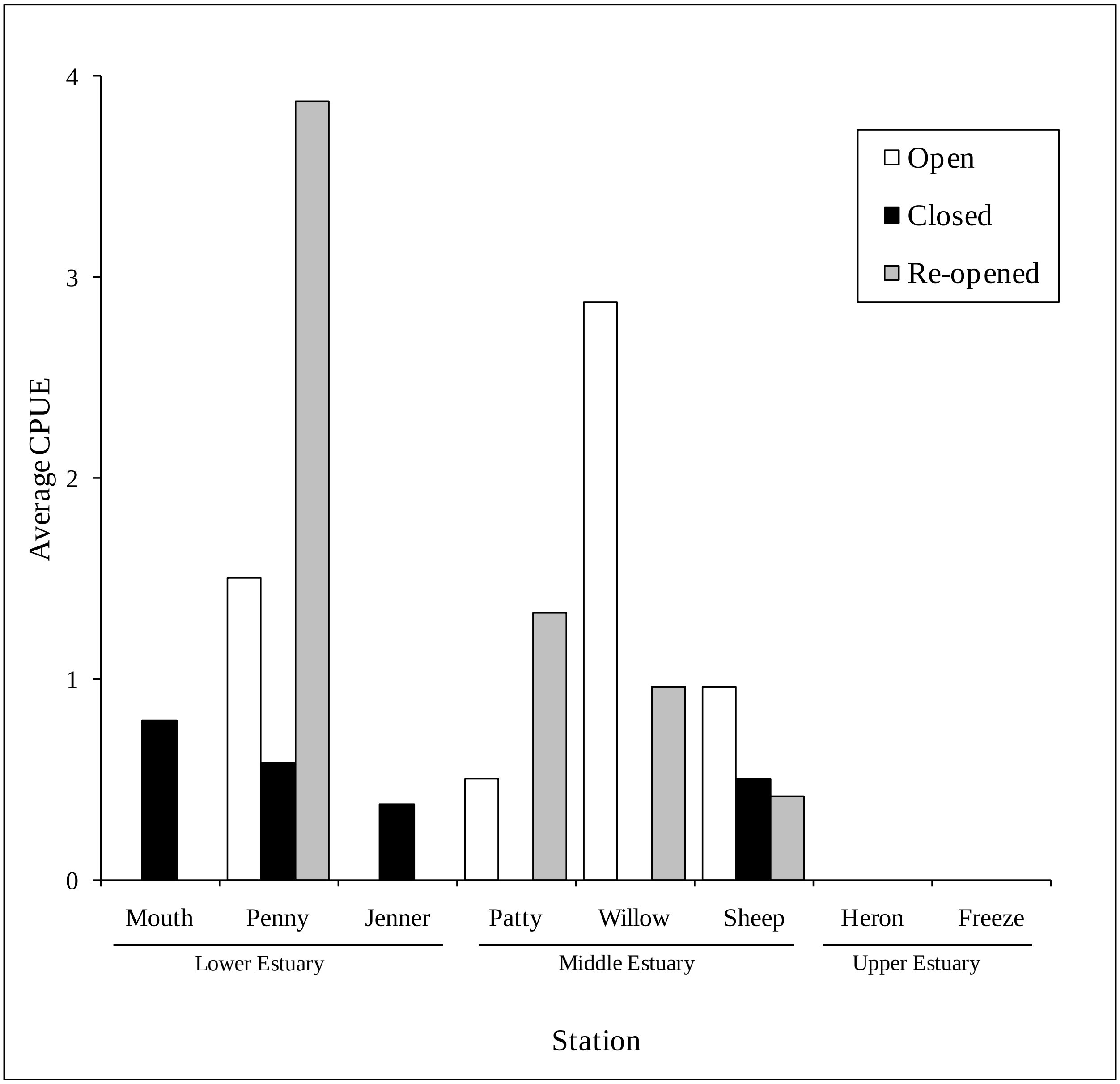

Figure 4.4.23: Topsmelt in the Russian River Estuary before, during, and after a mouth closure. Topsmelt are an estuarine species commonly found in the brackish waters in the Russian River Estuary. The river mouth closed for 29 days from September 6 to October 5, 2009. Surveys were conducted during August 31-September 2 (open), September 21- 23 (closed), and October 12, 21-22 (re-opened). Data is from eight beach seining stations with three seine pulls per station per seining event.

Staghorn sculpin is another common estuarine species in the Russian River Estuary. This sculpin is present in the Lower and Middle Estuary (Figure 4.4.24). During the mouth closure staghorn sculpin were restricted to three seining stations and their numbers appeared to decline. After the mouth reopened staghorn sculpin were only found at Penny Island station.

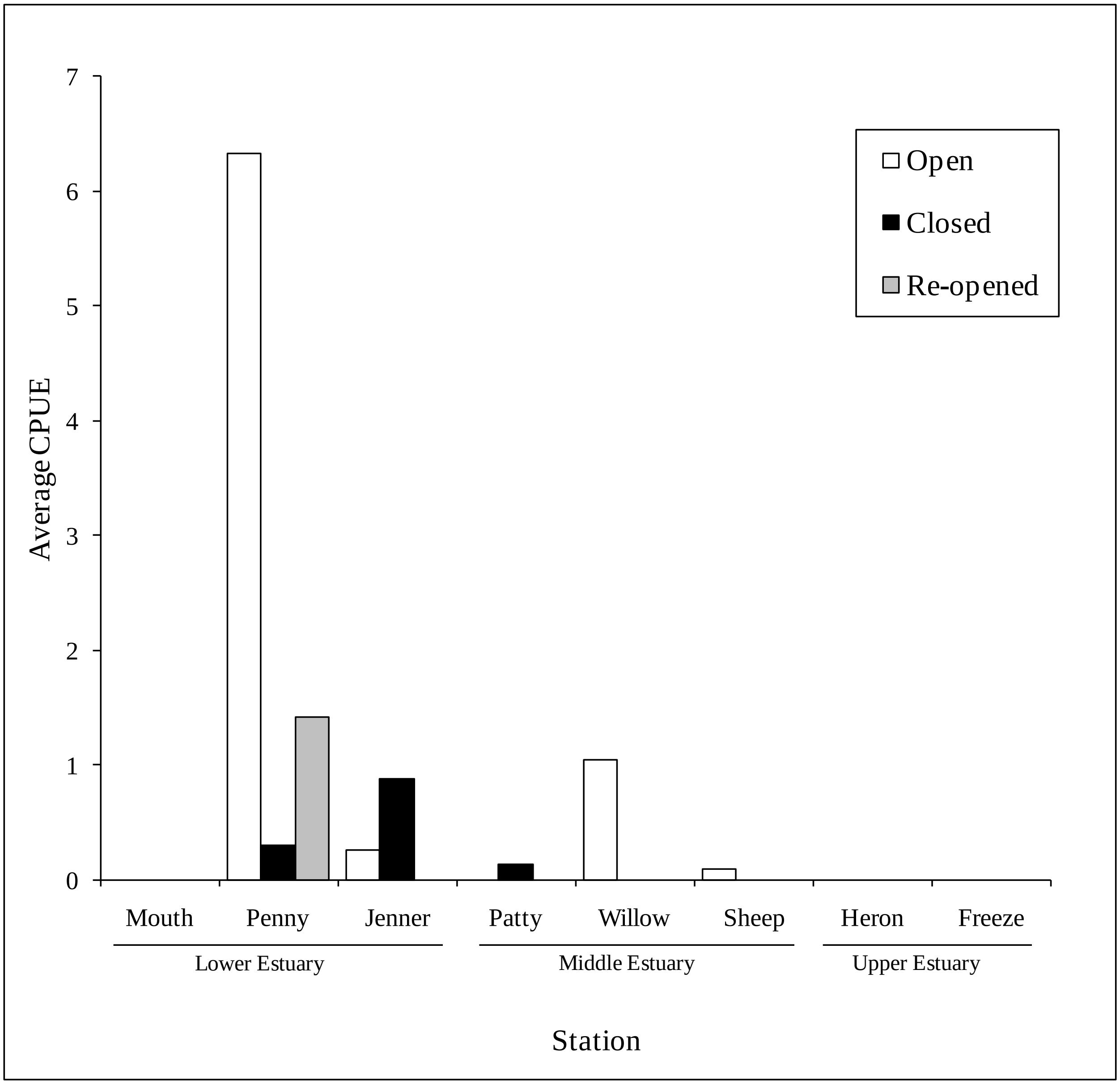

Figure 4.4.24: Staghorn sculpin in the Russian River Estuary before, during, and after a mouth closure. Staghorn sculpin are an estuarine species commonly found in the brackish waters in the Russian River Estuary. The river mouth closed for 29 days from September 6 to October 5, 2009. Surveys were conducted during August 31-September 2 (open), September 21- 23 (closed), and October 12, 21-22 (re-opened). Data is from eight beach seining stations with three seine pulls per station per seining event.

Table 4.4.3 summarizes the captures of salmonids before, during, and after the Russian River mouth closure. Only 13 juvenile steelhead were captured during the three mouth conditions. Most steelhead were caught at the Jenner Gulch and Sheephouse Creek stations. There were 10 Chinook salmon smolts captured before the mouth closure and one captured during the closure. No Chinook salmon smolts were detected after the mouth re-opened. Based on annual surveys since 2004, most Chinook salmon smolts pass through the Estuary by mid-July. The smolt captures in early and late September 2009, regardless of mouth condition, is unusual. No coho salmon were captured during September 2009. The latest capture of coho smolts in the Estuary during 2009 was on June 8.

Table 4.4.3: Summary of salmonid captures in the Russian River Estuary during open, closed, and reopened mouth conditions. The river mouth closed for 29 days from September 6 to October 5, 2009. Surveys were conducted during August 31-September 2 (open), September 21-23 (closed), and October 12, 21-22 (re-opened). Data is from eight beach seining stations with three seine pulls per station per seining event.

River Mouth Condition	Seining Station								Total
	River Mouth	Penny Island	Jenner Gulch	Patty Rock	Willow Creek	Sheep-house Creek	Heron Rookery	Freeze-out Bar	
Steelhead									
Open			1			5			6
Closed			1			2		1	4
Re-opened						3			3
Chinook Salmon									
Open		1	3	6					10
Closed	1								1
Re-opened									0
Coho Salmon									
Open									0
Closed									0
Re-opened									0

Conclusions and Recommendations

Fish Sampling - Beach Seining

The results of fish surveys from 2003 to 2009 found a total of 46 fish species from marine, estuarine, and riverine origins. The distribution of species was strongly influenced by the salinity gradient in the Estuary that is typically cool seawater near the mouth of the Russian River and warmer freshwater at the upstream end with a stratified mixing zone in the middle. Exceptions to this distribution pattern were anadromous fish that occurred throughout the Estuary regardless of salinity levels.

Although beach seining is widely used in estuarine fish studies, they are typically restricted to near shore, open water habitats that influence the detection of fish (Steele et al. 2006). Our seining stations were located in areas with few underwater obstructions (i.e., large rocks, woody debris, etc), which is necessary to deploy and retrieve the seine. Our seining method likely influenced the detection of fishes and evaluation of the distribution and abundance of fishes in the Estuary.

The distribution and abundance of salmonids in the Estuary differed spatially, temporally, and by species. Steelhead were caught throughout summer and early fall indicating steelhead do rear in the Estuary. The fluctuation in abundance of steelhead annually is likely attributed to the variability in the residence time of young steelhead before out-migration, schooling behavior that affects seine captures, and cohort strength. Chinook salmon smolts spent less than half the summer rearing in the Estuary and were usually no longer captured in the Estuary after July. Based on the detection of these smolts at most seining stations, they appear to use most estuarine habitats as they migrate to the ocean. In comparison, steelhead were found during the entire summer and were usually found in the Middle Reach. There were relatively few, but increasing, numbers of coho salmon smolts in the Estuary during the seven years of study. Most coho were caught early in the season and were hatchery-born fish.

The prolonged mouth closure in September-October 2009 had limited effect on salmonids. This late-season closure occurred when most coho salmon and Chinook salmon smolts had already migrated to the ocean. Although juvenile steelhead occur in the Estuary into late summer, typically fewer steelhead are seined in September and October than in early months. Six steelhead were caught prior to the mouth closure and 7 steelhead were caught during or after the mouth closure. These low numbers are insufficient to characterize the beneficial or negative effects of the closure on steelhead rearing in the Estuary.

To increase the statistical power to detect temporal and spatial differences in CPUE, seining efforts will be intensified in 2010. New fish sampling methods will include seining 25 sites in the lower Estuary and 25 sites in the upper Estuary. Each site will be sampled monthly from May to October.

4.5 Crab and Shrimp Trapping

Methods

Trapping surveys were used to determine the relative abundance and distribution of macro-invertebrates in the Estuary. These surveys focused on marine species in the Lower and Middle reaches of the Estuary. Six permanent trap stations were distributed between the Russian River mouth and 6.4 km (4.0 mi) upstream in a variety of habitat types based on substrate type (e.g., mud, sand, gravel, rock; Figure 4.4.1). Traps were set approximately every 4 weeks from June to September annually. One shrimp trap and one crab trap baited with fish parts at each station. Traps were deployed during the morning and retrieved 24 hours later. Captured invertebrates were identified to species, measured, and released. Age classes of Dungeness crabs (*Cancer magister*) were separated by an evaluation of size frequency data. For age class determination, we used ranges of carapace widths to incorporate summer growth of a cohort.

Age class and carapace width categories were: age 0+/young-of-the-year (<60-75 mm); age 1+ (60-75 mm to 90-100 mm); and adult (≥90-100 mm).

Results

Our trapping studies have documented 8 freshwater and marine species in the Estuary (Table 4.5.1). Signal crayfish (*Pacifasticus leniusculus*) and red swamp crayfish (*Procambarus clarkii*) are both freshwater, non-native, invasive species that occur in the Upper Estuary. The most commonly encountered species were Dungeness crab (*Cancer magister*) and bay shrimp (*Crangon stylirostris*). Fish seining surveys commonly capture bay shrimp at all fish seining stations from Freezeout Bar to River Mouth stations and Dungeness crab from Sheephouse Creek to River Mouth stations, as discussed below. Other marine macro-invertebrates found since 2004 include hairy rock crab (*Cancer jordani*), yellow shore crab (*Hemigrapsus oregonensis*), spot shrimp (*Pandalus platyceros*), and the invasive European green crab (*Carcinus maenus*).

Dungeness crab prefers sandy to sandy-mud bottoms and range from the intertidal zone to depths greater than 100 m. Adult Dungeness crabs spawn in the open ocean. The shrimp-like larvae are planktonic and drift with offshore currents (Morris et al. 1980). Larvae metamorphose into juvenile crabs from April to June and have a similar appearance as adults. Juveniles are bottom dwellers and rear in near-shore coastal waters, including estuaries (Wild and Tasto 1983). At least 2 years of age is required for sexual maturity.

Dungeness crab captures in the Lower Estuary differed substantially between adult and juvenile life stages, and crabs of any age class were rarely found upstream of Bridgehaven in the Middle Estuary (Figure 4.5.1). Age class 0+ Dungeness crab had the highest average CPUE in 2004 at 34.2 crabs/station. Then no juveniles were found the following year. In 2009 juvenile average CPUE was 4.0 crabs/station. Age 1+ crabs were rarely recorded. Adult captures ranged from 1.0 to 5.5 crabs/station. The captures of Dungeness crab were typically low in June and then increased with highest captures during August or September (Figure 4.5.2). In 2009 the highest captures of adults where in July and August. Although juvenile crabs appear absent during several years, hundreds to thousands of age 0+ crabs where caught during 2006 to 2009 during fish seining surveys, suggesting that young crabs use shallow water habitats in the Estuary. Also, fish seining surveys found juvenile crabs as far upstream as Sheephouse Creek station.

The European green crab is an invasive species that was first introduced to the San Francisco Bay in the 1980s and since has invaded other Pacific Coast estuaries. This crab has decimated fisheries on the East Coast. The European green crab was first found in the Estuary in 2005 and appears to occur in low numbers. No green crabs were found in 2009 (Table 4.5.1).

Table 4.5.1. Presence and absence of macro-invertebrates trapped in the Russian River Estuary, 2004-2008 and total captures at each station from June to October, 2009. *Incidentally captured during fish seining surveys in the vicinity of trap stations.

		Yr					2009						
Family *Species*	Common Name	04	05	06	07	08	River Mouth	Upper Penny Island	Bridge-haven	Willow Creek	Sheep-house Creek	Lower Heron Rookery	Total Catch
ASTACIDAE													
Pacifasticus leniusculus	signal crayfish	X	X									1	0
CAMBARIDAE													
Procambarus clarkii	red swamp crayfish		X										0
CANCERIDAE													
Cancer magister	Dungeness crab	X	X	X	X	X	54	35	55	29	19	1	193
Cancer jordani	Hairy rock crab		X										0
CRANGONIDAE													
Crangon stylirostris	bay shrimp	X	X	X	X								*
GRAPSIDAE													
Hemograpus oregonensis	yellow shore crab		X										0
PANDALIDAE													
Pandalus platyceros	spot shrimp				X								0
PINNOTHERIDAE													
Carcinus maenus	European green crab		X	X	X	X							0

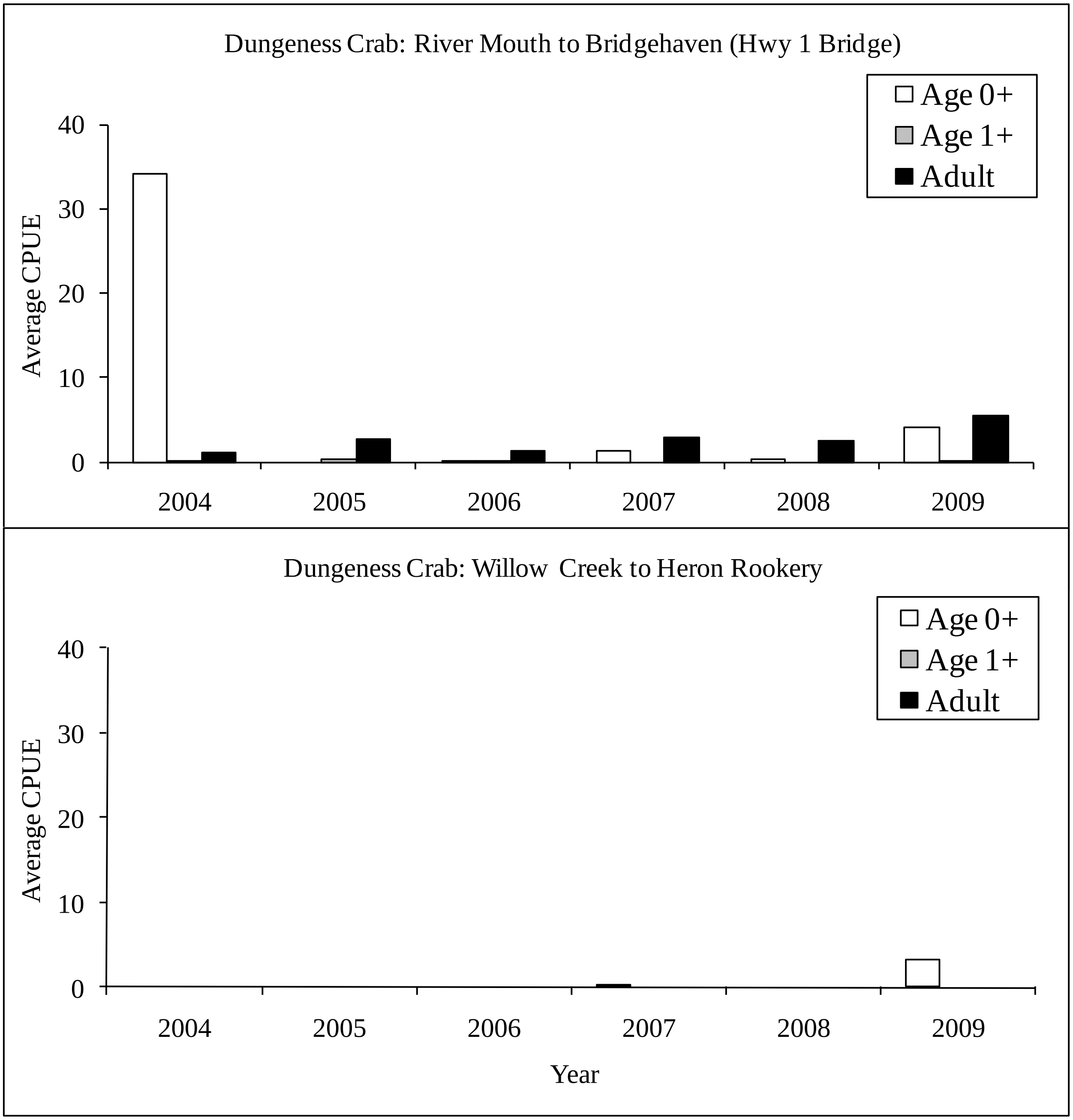

Figure 4.5.1: Average CPUE of Dungeness crab in the Lower and Middle Estuary from 2004 to 2009. Each station consisted of a crab trap and shrimp trap. Age classes are based on carapace widths. No trapping was conducted in 2004 from Willow Creek to Heron Rookery.

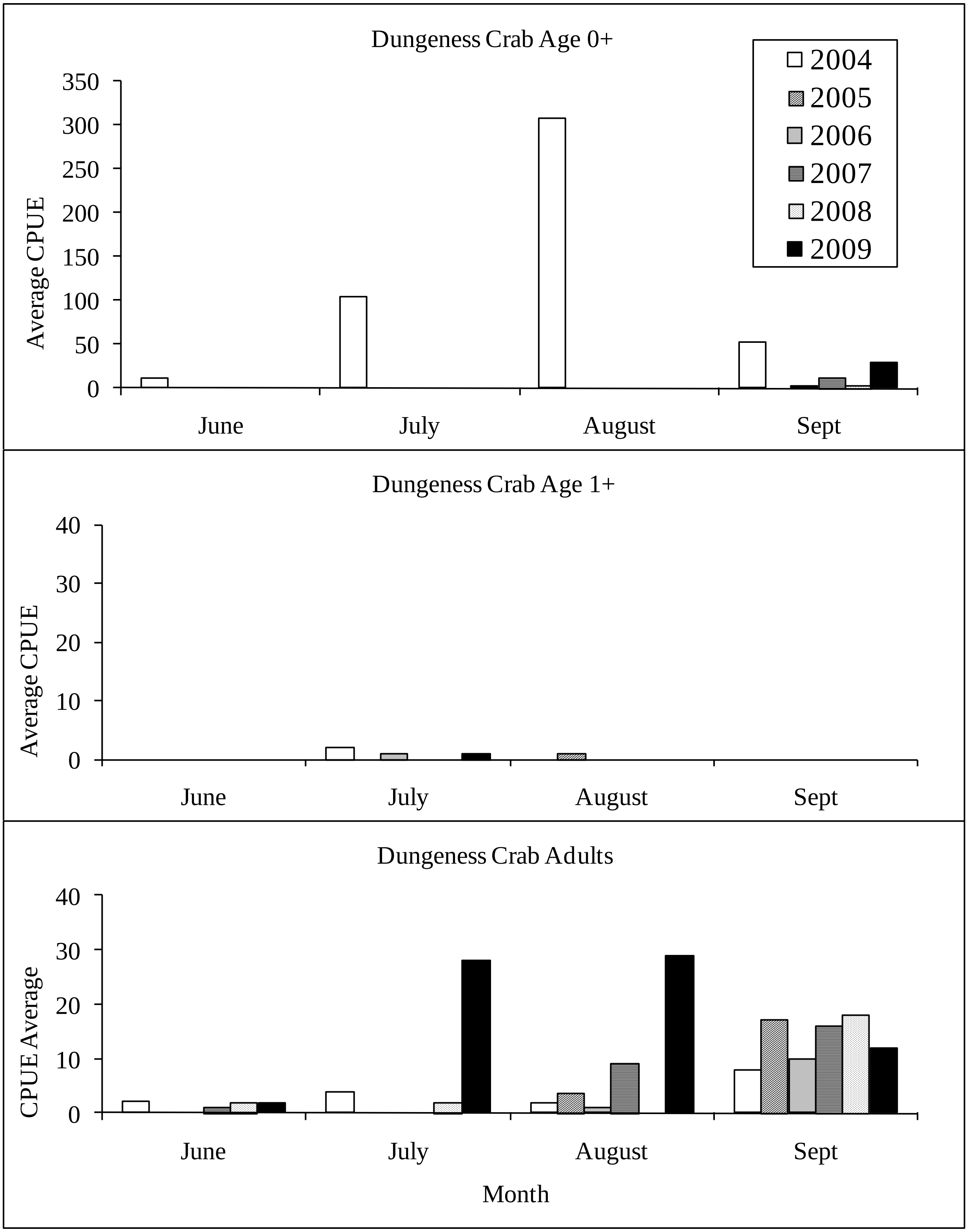

Figure 4.5.2: Seasonal average CPUE of Dungeness crab in the lower and middle Estuary from 2004 to 2009. Each station consisted of a crab trap and shrimp trap. Age classes are based on carapace widths.

Conclusions and Recommendations

Crab and Shrimp Surveys

The 2004 data indicated that the Estuary is a nursery for juvenile Dungeness crabs; however, none or few juveniles were caught in subsequent years from 2005 to 2009. The Russian River mouth remained open during most of the spring seasons in 2004 through 2009 when juvenile crabs would move to inshore areas and estuaries. The prevailing open-mouth conditions indicate that there was unrestricted access for crabs to the Estuary. The only spring sandbar closure was from 2 May to 4 May 2004, which was the year with an abundance of juvenile Dungeness crabs in the Estuary. Atypical winter ocean temperatures and currents, and low ocean productivity, may explain the bust or boom pattern of juvenile crabs. These ocean conditions can affect larval Dungeness crab survival and migration to inshore areas and estuaries. In 2005, this pattern occurred in the San Francisco Bay, which is an important nursery for young Dungeness crab, where no juveniles were recorded (Kathy Hieb, California Department of Fish and Game, pers. comm.).

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5: Dry Creek Habitat Enhancement, Planning, and Monitoring

5.1 Dry Creek Habitat Enhancement

The Biological Opinion contains an explicit timeline that prescribes a series of projects to improve summer and winter rearing habitat for juvenile coho salmon and steelhead in Dry Creek (Table 5.1.1). During the initial three years of implementation, 2008 to 2011, the Water Agency is charged with improving fish passage and habitat in selected tributaries to Dry Creek and the lower Russian River. The status of those efforts is described in Chapter 6 of this report. For the mainstem of Dry Creek, during this initial period, the Water Agency is directed to perform fisheries monitoring, develop a detailed adaptive management plan, and conduct feasibility studies for large-scale habitat enhancement and a potential water supply bypass pipeline.

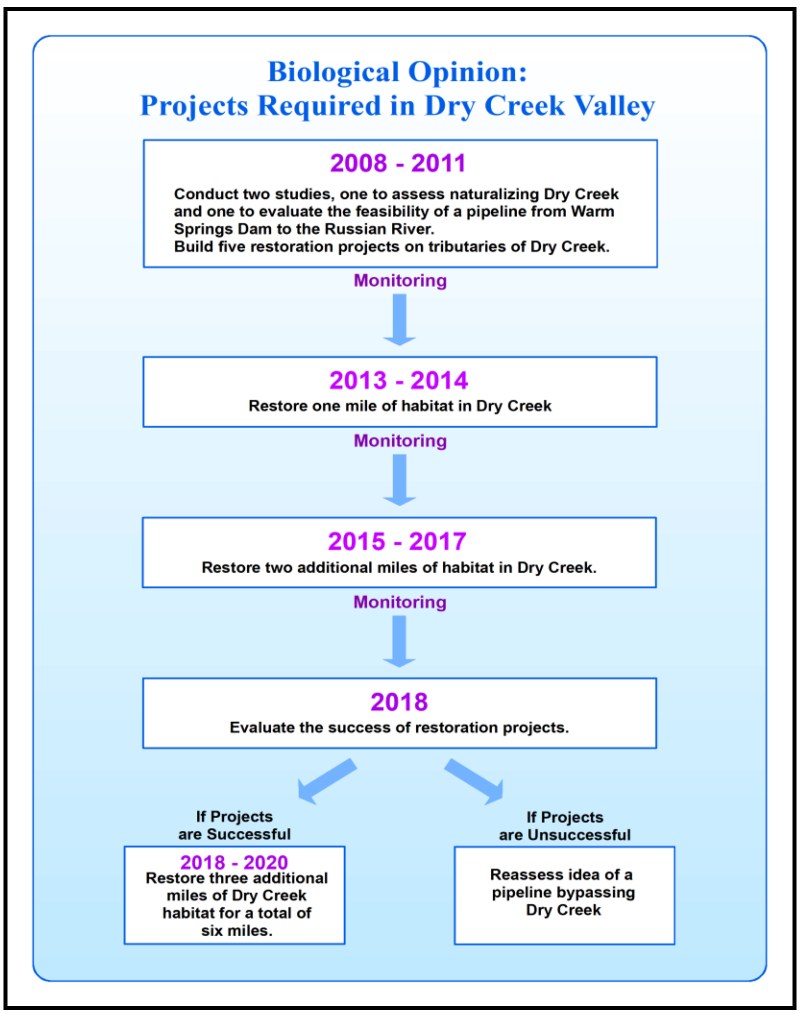

Figure 5.1.1. Timeline for implementation of Biological Opinion projects on Dry Creek.

Habitat Enhancement Feasibility Study

Current Conditions Inventory

The Water Agency regulates summer releases from Warms Springs Dam along a 14 mile reach of Dry Creek from Lake Sonoma to the Russian River. This abundant, cool, high quality water has tremendous potential to enhance the Russian River's coho and steelhead population but it flows too swiftly to provide maximum habitat benefit. By modifying habitat conditions to create refugia from high water velocities along 6 miles of Dry Creek, NMFS and DFG assert that water supply releases can continue at current discharge levels of approximately 100 cubic feet per second (cfs).

To plan large scale enhancement of the Dry Creek channel, the Water Agency has retained Inter-Fluve, Inc. to conduct extensive field surveys and produce a series of reports. In 2009, Inter-Fluve completed a current conditions inventory of Dry Creek habitat conditions (Appendix D-1). The Current Conditions Report includes a review of existing data regarding Dry Creek hydrology, geomorphology, and habitat conditions; analysis of Dry Creek basin hydrology; results of a reconnaissance survey and analysis of geomorphic conditions; inventory and analysis of fish habitat conditions; and identification of potential enhancement sites. Results of the Current Conditions Report will be used to inform a detailed feasibility study for the potential enhancement sites. The detailed feasibility study will be completed in 2011.

Based on geomorphological characteristics, Interfluve delineated 16 subreaches along Dry Creek and the current conditions inventory provides the most comprehensive analysis of Dry Creek habitat to date. The study confirmed many assertions in the Biological Opinion regarding high water velocity and the simplification of habitat that resulted from historic practices and the current operation of Warm Springs Dam. The explosive growth riparian vegetation along the stream margins in the 26 years since dam completion has stabilized gravel bars, concentrated flow in the center of the stream channel, and accelerated water velocity. While pools are abundant, shallow riffle habitats, side channels, alcoves, and backwaters are not and the composition of habitat types is sub-optimal for coho salmon and steelhead rearing.

Although Dry Creek flows through a deeply incised channel, the stream corridor contains relict gravel bars, terraces, and sufficient width in many areas to allow development of off-channel low velocity habitats. In their review of potential enhancement opportunities, Inter-Fluve identified dozens of locations that are amenable to habitat modification at the spatial scale contemplated in the Biological Opinion. While detailed plans will be revealed in the full feasibility study, the results of the current conditions inventory are encouraging.

Demonstration Project

As described in the Public Outreach Chapter of this report, the Water Agency must engage a diverse group of stakeholders to implement the Biological Opinion. Dry Creek is held almost entirely in private ownership and Water Agency staff must work in concert with landowners of more than 170 parcels to study, plan, and construct habitat enhancements. The Biological Opinion's 5 year timeline prior to construction of the first mile of habitat enhancement acknowledges this challenge and the depth of study, planning, and environmental compliance required for implementation. A forward looking group of property owners along a one mile stretch of the stream near Lambert Bridge, in the middle of Dry Creek Valley, approached the Water Agency with the opportunity advance the schedule and demonstrate habitat enhancement techniques in their reach of the stream. The Water Agency has welcomed this opportunity, and worked throughout 2009 to develop the Dry Creek Habitat Enhancement Demonstration Project. Inter-Fluve is working simultaneously on the habitat enhancement study for the full 14 mile length of Dry Creek and detailed engineering designs for the demonstration mile. In early 2010, Inter-Fluve produced a 10 percent conceptual design that describes enhancement techniques and their potential location along the one-mile reach (Appendix D-2). In close consultation with NMFS and DFG, Inter-Fluve is advancing the design to the 30, 60, and 90 percent phases in 2010 and 2011. Water Agency staff is preparing documents to comply with CEQA and prepare regulatory agency permits needed for construction in summer 2012.

Adaptive Management and Monitoring Plan

While the Biological Opinion contains a general timeline for Dry Creek projects, the complexity of the habitat enhancement effort requires a detailed adaptive management plan to ensure monitoring data can inform each phase of implementation. In 2009, the Water Agency retained ESSA Technologies, Inc. to develop such a plan and work closely with NMFS and DFG to transform Biological Opinion objectives in Dry Creek into measurable targets and performance metrics. During 2010, ESSA is held a series of workshops with the agencies, including USACE, to build the decision trees and guidelines for a state-of-art adaptive management plan. Planning for work in the Demonstration Project mile is being used to develop an adaptive management framework that can be applied to subsequent phases of the Dry Creek Habitat Enhancement Project.

Pipeline Bypass Feasibility Study

The Dry Creek Bypass Pipeline Feasibility Study is being conducted to evaluate the feasibility of constructing a raw water pipeline that would bypass flows from Warm Springs Dam around Dry Creek to the Russian River. Should 3 miles of the habitat enhancements efforts described above prove ineffective by 2018, the Water Agency must draw upon the results of the feasibility study to advance planning and construction of a bypass pipeline (Figure 5.1.1). The three primary components being evaluated are the pipeline inlet structure, the pipeline route, and an outlet structure. Additionally, the study is evaluating the potential to increase hydroelectric generation capacity. Objectives of the study are to identify uncertainties and potentially significant issues associated with the proposed bypass pipeline, develop and evaluate project alternatives including construction costs, and identify the preferred project alternative. Once the Feasibility Study is complete, an Engineering Study will be conducted to support the environmental document that will ultimately be developed for the proposed project.

The Water Agency entered into an Agreement with HDR Engineering to conduct the Feasibility Study and subsequent Engineering Study in December, 2008. After receiving landowner access during Spring, 2009, HDR conducted a physical site reconnaissance to identify potential constructability issues and identify any potential for hazardous materials contamination in the vicinity of any of the proposed pipeline routes. Once the initial site reconnaissance was complete, HDR identified several project alternatives to be evaluated for the study. HDR evaluated multiple variations on three primary routes. The three primary routes were; 1) down the east side of Dry Creek Valley; 2) the west side of Dry Creek

Valley; and 3) a route that went directly east to the Geyserville area. HDR also identified alternatives for the inlet structure and multiple locations for an outlet structure.

As the study developed, HDR produced several technical memos (TMs) that served to document the process and provide decision points for moving on with the study. The first TM entitled *Evaluation Methodology* (Appendix D-3) was submitted in July of 2009, and later revised in November of 2009, provided an outline for the evaluation of project alternatives and presented key criteria for which each alternative would be ranked. The next TM entitled *Screening Results for Inlet Works, Pipeline Route, and Outlet Works* was submitted in December of 2009 and later revised in March of 2010 provided a summary of the methodology and results of the facilities screening process. The final TM entitled Summary of Alternatives Evaluation, submitted in April of 2010, provided results of the alternatives evaluation and a ranking of the alternatives. Comments provided by Water Agency staff on this final TM will be incorporated into the pending Draft Feasibility Report, expected to be submitted in December of 2010. Throughout the process of developing the Feasibility Report, progress was reported to Water Agency staff and stakeholders including NMFS, DFG, USACE, North Coast RWQCB and the Dry Creek Advisory Group at key milestones for the study.

The Draft Dry Creek Bypass Pipeline Feasibility Report was submitted in December of 2010. Upon review of the document by Water Agency staff and key stakeholders, including the Water Agency's water contractors, a Final Feasibility Report will be completed by March, 2011. Additional work will continue on the Engineering Report through June, 2011.

5.2 Dry Creek Downstream Migrant Trapping

To validate the effectiveness of Dry Creek habitat enhancements and inform the adaptive management process, the Water Agency is conducting a number of salmonid monitoring activities in Dry Creek. One of these efforts is the operation of a 1.5 m rotary screw trap on Dry Creek to monitor population trends in juvenile Chinook salmon, coho salmon, and steelhead. The downstream migrant trapping effort began in 2009 with plans to continue until at least 2018.

Methods

A rotary screw trap with a 1.5 m diameter cone was anchored to the West Side Road bridge, located 3.2 km upstream from the confluence of Dry Creek and the Russian River (Figure 5.2.1). Weir panels were installed adjacent to the rotary screw trap in order to divert downstream migrating salmonids into the trap that may have otherwise avoided the trap.

Fish captured in the trap were identified to species and enumerated. A subsample of each species was anesthetized and measured for fork length each day, and a subsample of salmonid species was weighed each week. With the exception of Chinook, all fish were released downstream of the first riffle located downstream of the trap. Each day, up to 50 Chinook smolts ($\geq$50 mm) were finclipped and released approximately 100 m upstream of the trap for the purpose of estimating population abundance using program DARR (Bjorkstedt 2005). We also marked and released steelhead smolts in a similar fashion; however, capture efficiency of steelhead smolts was too low to calculate an accurate population estimate (see results). To represent capture efficiency for the season, we calculated a weighted season average obtained by summing the products of the number of fish marked each day and the proportion recaptured the next day then dividing the result by the number of fish marked for the season. Finclipped fish that were recaptured in the trap were noted and released downstream (the lengths and weights of recaptured fish were not recorded a second time). An assumption of the mark-recapture model is that marked fish are available for recapture. Because steelhead presmolts are not necessarily motivated to move downstream like smolts, this would represent a violation of that assumption; therefore, we did not attempt to estimate their population size and instead we simply report the trap catch.

We also installed and fished fry traps at Westside Road (river km 3.2) just downstream of the rotary screw trap site and at Yoakim Bridge just upstream of Yoakim Bridge (river km 17.1). Each trap consisted of a funnel on the upstream end fashioned by attaching rubber flaps to a lid of a five gallon plastic bucket. A slit was cut into the lid and the rubber flaps were inserted through the slit and tied off in the shape of a funnel. The lid was then snapped onto a perforated five gallon plastic bucket and the bucket was anchored to the stream bottom so that the funnel end faced upstream. Traps at both sites were installed on 4/1 and removed on 5/13 (Yoakim Bridge) and 5/19 (Westside Road) as well as periodically during high flows and most weekends. Traps were checked in the morning each day they fished.

Figure 5.2.1. Photograph of the rotary screw trap on Dry Creek located beneath the Westside Road bridge in Healdsburg, 2009.

Results

The rotary screw trap was checked daily during operation between April 7 and August 31 with the exception of April 15 when trapping was suspended due to the potential for high debris and associated mortality related to a wind storm (Figure 5.2.2). From April to mid June Chinook smolts were the most abundant fish caught in the trap. Based on the proportion of recaptures in the trap, capture efficiency for Chinook smolts (weighted season average=11.7%, Figure 5.2.3) was much higher than capture efficiency for steelhead smolts (weighted season average=2.5%). The population of Chinook smolts estimated to be migrating past the Dry creek screw trap in 2009 was 222,487 (95% CI: ± 15,627). Based on that estimate, May 17 marked the point at which one-half of the Chinook population had migrated past the rotary screw trap (Figure 5.2.4). A total of 180 steelhead smolts were captured; however, because capture efficiency was so low no population estimate was calculated meaning that this number should be interpreted as a minimum count. Steelhead presmolts became the most abundant fish caught after mid-June with a season total of 5,226 (Figure 5.2.5); in early July the catch of steelhead presmolts began to diminish. Coho were the least abundant of the 3 salmonid species captured; only 10 (7 hatchery-origin and 3 non-fin-clipped) were caught during the trapping season (Table 5.2.1). The weekly sizes of Chinook smolts (Figure 6) and steelhead presmolts (Figure 5.2.7) showed a generally increasing trend over the season. In addition to salmonids, 11 non-salmonid species were captured.

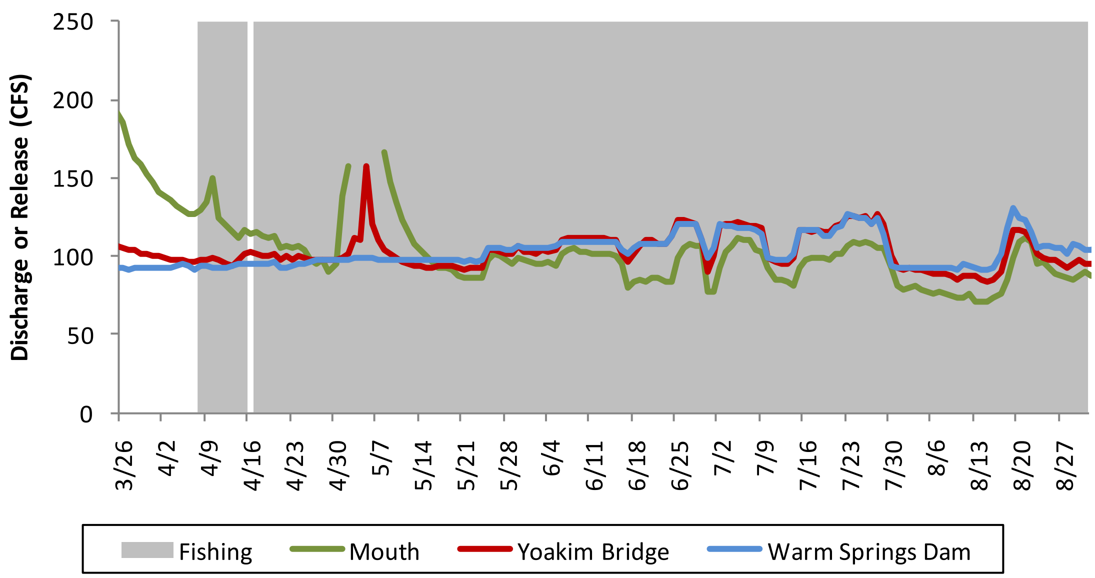

Figure 5.2.2. Releases from Warm Springs Dam (USGS gauge 11465000), discharge at Yoakim Bridge (USGS gauge 11465200), discharge at the mouth (USGS gauge 11465350) and the days the Dry Creek rotary screw trap fished, 2009. Note that the gauge at the mouth is a low flow gauge and is only valid for discharges <200 CFS.

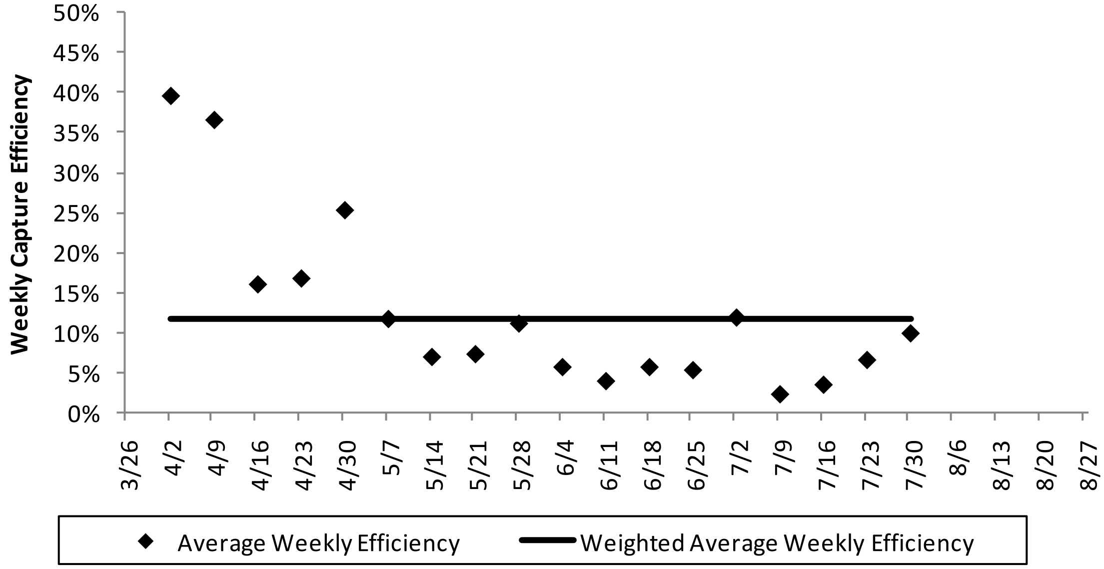

Figure 5.2.3. Weekly estimated capture efficiency and estimated overall average weekly capture efficiency for Chinook salmon at the Dry Creek rotary screw trap, 2009.

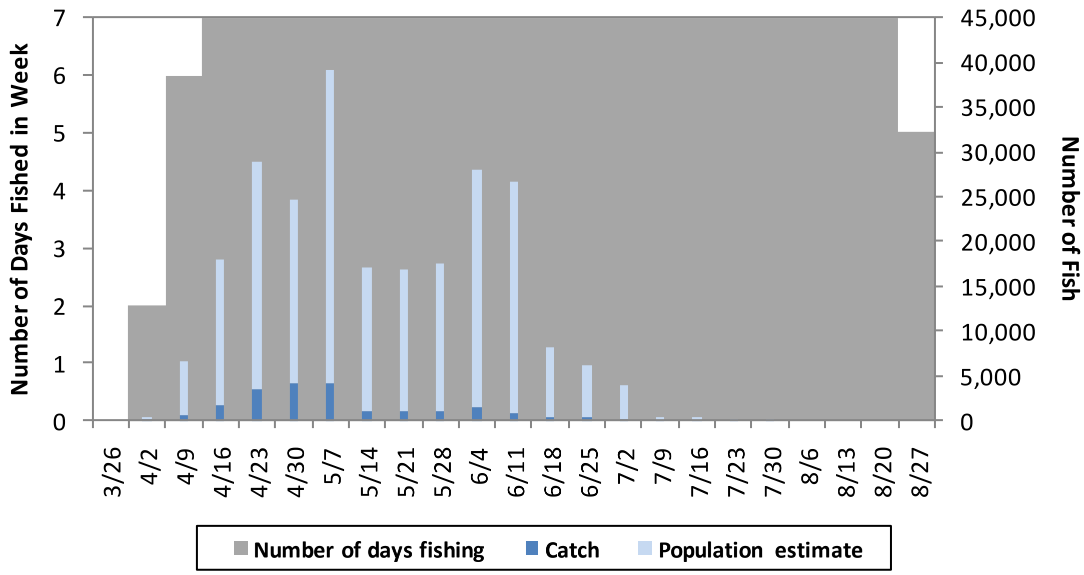

Figure 5.2.4. Weekly trap catch and population estimate of Chinook salmon smolts in the Dry Creek rotary screw trap, 2009. Note that the trap was installed on 4/6 (which was the week of 4/2) and that this week only consisted of 2 sampling days.

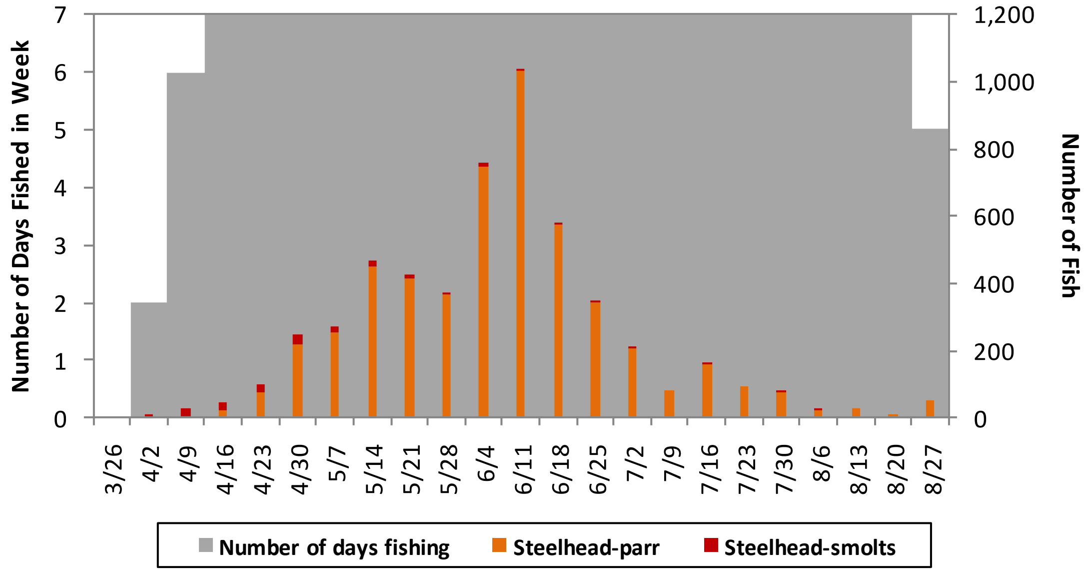

Figure 5.2.5. Weekly trap catch of steelhead presmolts and smolts in the Dry Creek rotary screw trap, 2009. Note that the trap was installed on 4/6 (which was the week of 4/2) and that this week only consisted of 2 sampling days.

Table 5.2.1. Weekly trap catch of coho salmon smolts in the Dry creek rotary screw trap, 2009.

Week	Hatchery	Wild
4/9	1	2
4/23	0	1
4/30	1	0
5/7	2	0
5/21	1	0
6/18	2	0

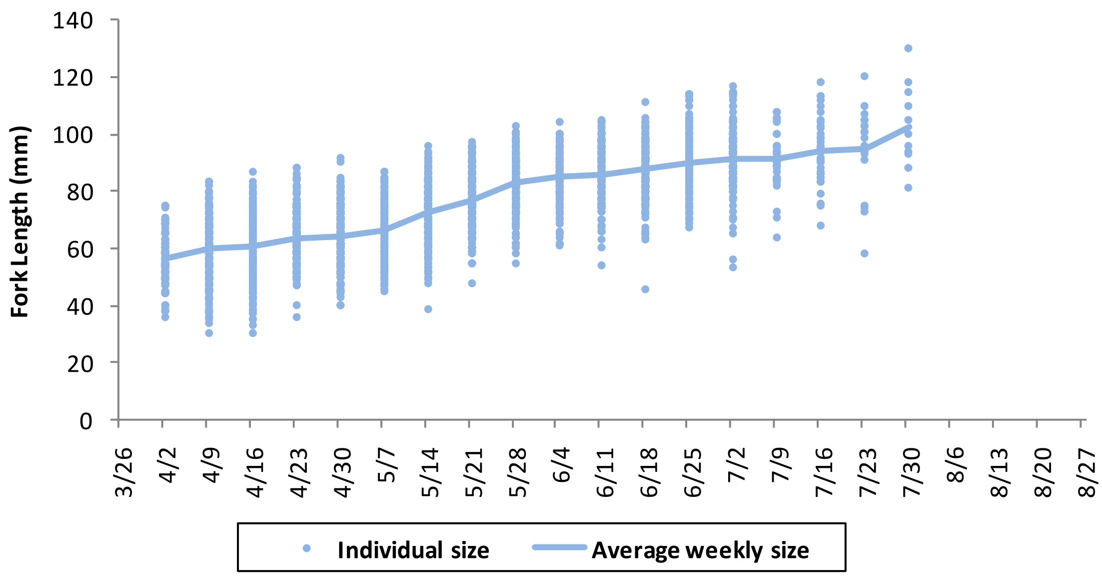

Figure 5.2.6. Fork lengths of Chinook salmon smolts caught in the Dry Creek rotary screw trap by week, 2009.

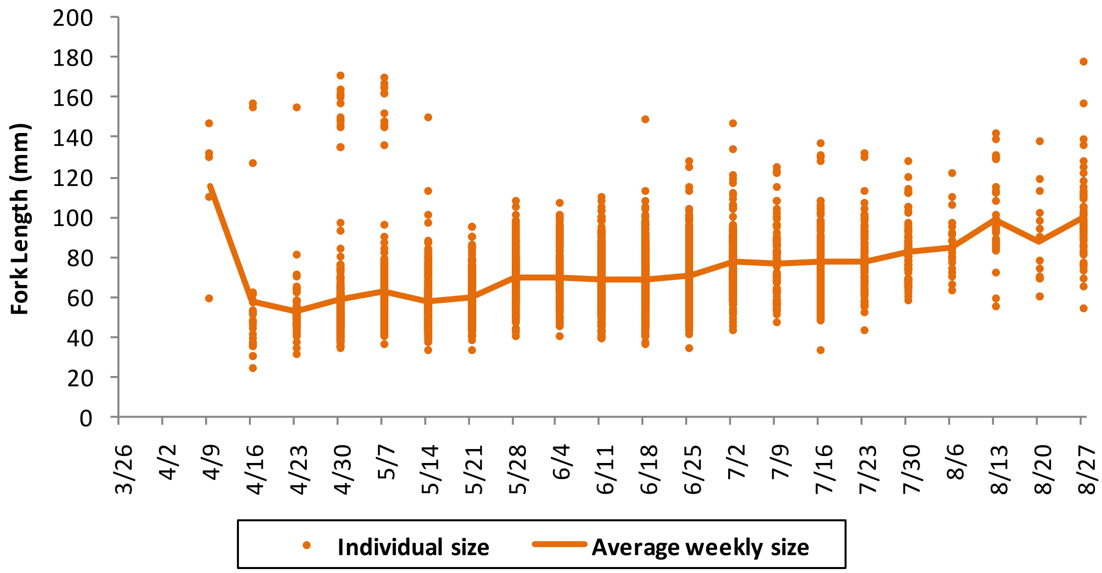

Figure 5.2.7. Fork lengths of steelhead presmolts caught in the Dry Creek rotary screw trap by week, 2009. Note that the larger individuals in the upper left-hand portion of the graph were classified as parr in the field but they may have been individuals that were indeed smolts that had not yet fully developed the morphology and coloration typical of smolts.

The fry traps at Yoakim Bridge were fished for 45 days and the fry traps at Westside Road were fished for 48 days. Capture of salmonid fry at the fry traps was low with 47 captured in the fry traps at Yoakim and only 1 captured in the fry trap at Westside Road. This was despite the fact that we observed dozens of fry milling about on the stream margins on several occasions. All fry captured appeared to be in good condition with no mortality observed. We were unable to identify individuals to species given their small size (sizes were generally in the 25-35 mm range).

Conclusions and Recommendations

In 2009, the peak daily release from Warm Springs Dam and peak daily discharge at Yoakim Bridge between April 1 and August 31 indicate that conditions were well within limits to safely and effectively operate a downstream migrant trap on Dry Creek (Figure 5.2.2). However, a retrospective analysis over the past 10 years suggests that the installation of the trap may be delayed until late April through late May in some years (Figure 5.2.8).

Our results from the 2009 trapping season support the conclusion that Dry Creek is an important resource for Chinook salmon and steelhead in the Russian River basin. The increasing trend in body size over time for both Chinook smolts and steelhead presmolts suggests that conditions in Dry Creek during this time of year are favorable for positive body growth.

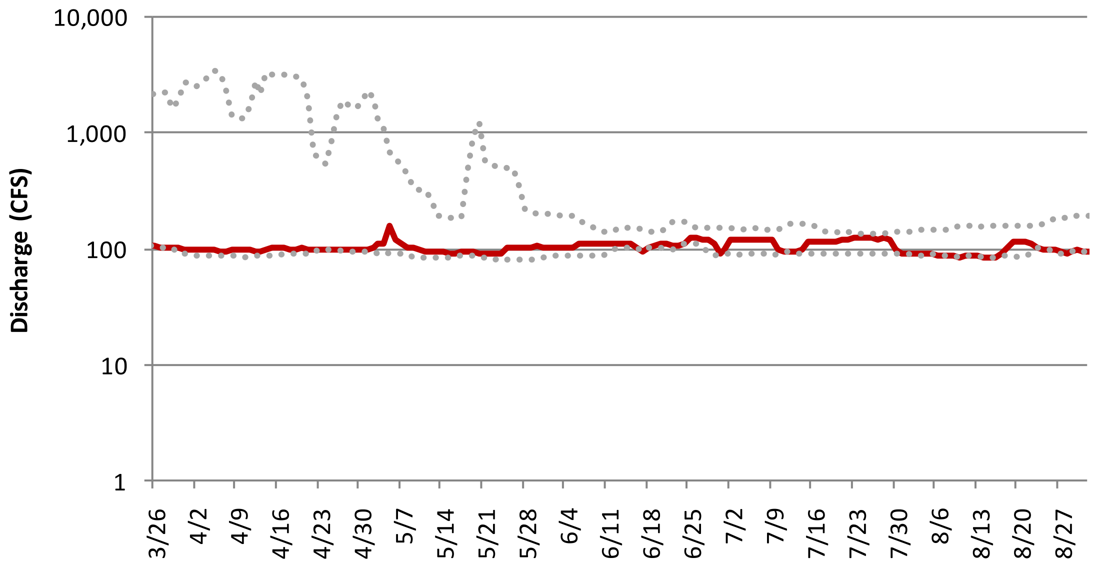

Figure 5.2.8. Daily discharge in 2009 (solid line) and daily minimum and maximum discharge (dashed lines) in 2000-2009 at Yoakim Bridge (USGS gauge 11465200). Period encompasses 3/26-8/31. Note that the vertical scale is $\log_{10}$.

We speculate that the decrease in capture efficiency for Chinook smolts beginning in early May (Figure 5.2.3) could have been related to a change in the speed with which the cone on the trap turned as water velocities slowed (e.g., slower speeds mean fish could more easily evade capture). Another explanation is that the mean size of individuals began to exceed some size threshold above which their swimming ability allowed them to more easily avoid capture (Figure 5.2.6). Whatever the cause, we are comfortable basing our population estimate for Chinook smolts in 2009 on these capture efficiencies. The estimate of Chinook emigrating past the Dry Creek rotary screw trap in 2009 **(**222,487 +/- 15,627) in itself is a large number but it also represents a significant portion of what is generally estimated to be migrating past the Wohler-Mirabel during the same period (Chase 2005). This finding is also consistent with Cook et al. (2008) who found that Dry Creek was heavily used for Chinook spawning in past years.

Although abundance estimates of steelhead presmolts were not possible using mark-recapture methods because of violations of the assumptions of mark-recapture models, frequent and numerous capture of presmolts (n=5,226) suggests that significant numbers of steelhead are produced in Dry Creek. The small catch of steelhead smolts (n=180) is probably due to low trap efficiencies for that species/life stage combination. Chase et al. (2005) found that the peak emigration period for steelhead smolts in the mainstem Russian River was between mid-March and mid-May when downstream migrant trapping is typically not feasible. This phenomenon, coupled with generally low capture efficiencies of steelhead smolts, suggests that the use of downstream migrant traps as a means of accurately estimating the abundance of steelhead smolts produced in Dry Creek is probably not practical.

Coho were infrequently encountered in the Dry Creek rotary screw trap in 2009 despite the fact that 9,980 coho smolts from Warm Springs hatchery were stocked into mainstem Dry Creek on 3/26 (12 days prior to commencement of Dry Creek trapping operations). This information confirms the low abundance of natural spawners or juveniles in mainstem Dry Creek. It also confirms observations associated with the coho broodstock monitoring program that stocked coho smolts move out of their stocking stream rapidly (M. Obedzinski personal communication). As of the 2009 downstream migrant trapping season, none of the tributaries upstream of the Dry Creek rotary screw trap had been stocked with coho salmon (Obedzinski et al. 2008).

We recommend continuing to operate the downstream migrant trap on Dry Creek as operated in 2009 and as outlined in the Biological Opinion. This will provide important data for validating the efficacy of eventual habitat enhancement measures on Dry Creek status as well as documenting the status and trends of Chinook salmon production in Dry Creek. Because of the capture efficiency for steelhead smolts, we recommend discontinuing finclipping and releasing steelhead smolts upstream of the trap in attempt to obtain a mark-recapture-based population estimate. The only salmonid species captured in August was presmolt steelhead. By the end of August, catches had diminished to less than 10 individuals on most days. We recommend continuing to operate the trap through the end of August in 2010; however, we also recommend re-visiting whether operating beyond July 31 is necessary in order to meet the objectives of the Biological Opinion after the 2010 season.

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5.3 Juvenile Salmonid Sampling

The Russian River Biological Opinion outlines a plan for the Sonoma County Water Agency to enhance 6 miles of mainstem Dry Creek in an effort to improve coho and steelhead rearing habitat. The Biological Opinion further states that the Water Agency, in conjunction with NMFS and DFG, will develop a post-construction adaptive management, monitoring, and evaluation plan that will identify project goals, objectives, and success criteria. That process is currently underway in the form of a multi-agency group, facilitated by ESSA Technologies Ltd. (an independent consulting firm from Vancouver Canada), that will develop an adaptive management framework, involving all parties to the biological opinion, together with other experts, in an iterative process of meetings and discussions. The Water Agency intends to use the adaptive management framework developed through this process as the basis for the adaptive management plan described in the Biological Opinion.

The adaptive management plan resulting from this process will contain a component designed to validate the effectiveness of eventual habitat enhancements in Dry Creek by measuring the biological response in mainstem Dry Creek. In 2008, the Water Agency began to evaluate appropriate sampling approaches for monitoring that response. Although an important part of the validation monitoring in Dry Creek will include downstream migrant trapping, that information is covered in the preceding section of this report. Instead, the focus of the current chapter is on validation monitoring as it relates to juvenile (presmolt) life stages of coho salmon and steelhead while they reside in mainstem Dry Creek.

Much of the Water Agency's juvenile salmonid sampling efforts to date in mainstem Dry Creek have centered on evaluating which metrics and associated sampling options are best-suited to detecting a biological response to eventual habitat enhancements. As the Water Agency has previously described (Water Agency 2009), many of the more common juvenile salmonid sampling techniques that are suitable in small streams are simply not feasible to use in mainstem Dry Creek; because of this, the Water Agency has developed and evaluated some alternative sampling approaches that are described below. Upon completion of that evaluation, the Water Agency will incorporate their findings into specific recommendations that form the basis of a monitoring plan for NMFS and DFG to consider.

In this chapter, we outline the population-related metrics we are considering for the purpose of juvenile salmonid validation monitoring in mainstem Dry Creek as well as a description of the monitoring approaches that we believe will allow us to best approximate those metrics. We then describe our approach to evaluating each of those methods as well as the outcome of each evaluation. Next, we present some estimates generated from those estimates as well as from what we feel is an approach that offers promise as a way to overcome some of the challenges to sampling presented by current conditions in Dry Creek. We conclude by outlining an overall framework for conducting juvenile salmonid monitoring in Dry Creek in future years. Our intent is to vet that framework with NMFS, DFG, Interfluve, and ESSA during the process of developing the adaptive management framework.

Methods

Population metrics

We considered six candidate metrics as possibilities for measuring the success of eventual habitat enhancement efforts in mainstem Dry Creek: abundance (density), size, habitat use, survival, growth, and reach fidelity. In order to obtain estimates of those metrics, we considered the following sampling methods: electrofishing, snorkeling, PIT-tagging and PIT-tag detection with PIT antenna wands and at stationary antennas, and downstream migrant trapping. All sampling discussed in the current chapter was conducted at normal, summer-time discharges from Lake Sonoma (approximately 100-110 cfs).

Abundance (density)

We attempted to maximize the spatial extent of our sampling to include as much of the 22 km length of Dry Creek as possible. We chose sections that appeared to offer conditions amenable to holding in-stream equipment (e.g., block mesh panels, PIT antennas) and that could be safely waded or snorkeled. This resulted in sites in three main areas that were sampled by backpack electrofishing using snorkeling and/or electrofishing surveys (Figure 5.3.1). The Petersen mark-recapture model in program MARK (White and Burnham 1999) was used to generate estimates of capture probabilities and abundance for all mark-recapture electrofishing samples.

Electrofishing. In 2009, we began the sampling season by continuing to evaluate the feasibility of temporarily closing short sections of mainstem Dry Creek in order to satisfy the assumptions of mark-recapture models (Figure 5.3.1, sampling on September 10, and September 11). At two sites, we installed 15 mm mesh filled wooden panels (hereafter referred to as mesh panels) that spanned the stream at the boundaries each stream section with the intention of conducting a multiple-pass depletion estimate in each section. The panels were fortified with multiple "T"-posts driven into the streambed. A pass was defined as the combination of downstream to upstream sampling followed immediately by upstream to downstream sampling for the entire length of the section.

Snorkeling. In 2009, we also continued our evaluation of snorkeling as a means to estimate juvenile salmonid abundance in mainstem Dry Creek. Snorkel surveys were conducted at three of the same sites where electrofishing was also conducted (Figure 5.3.1) which gave us the ability to compare counts from the two methods. Because we conducted multiple-pass snorkeling at two of these sites, we were also able to compare estimates generated with the bounded count estimator (snorkeling) to estimates generated with the Petersen estimator (electrofishing).

Petersen estimates and "core" areas. Because of our failure to maintain geographic closure both in 2008 and in 2009 (see Results section), we abandoned our efforts to estimate density using multiple-pass depletion with electrofishing. Similarly disappointing was the generally poor comparison of electrofishing-based counts to counts obtained from snorkeling surveys (see Results section). Instead, we relied on Petersen mark-recapture estimates at four sites. At two of the four sites, we evaluated a new idea that involved directly estimating the extent to which fish were exiting a stream section of interest (the "core") and using these estimates to adjust the Petersen estimate for that core area. The method depended on: (1) electrofishing and PIT-tagging fish in the core area on day 1; (2) electronic detection of PIT-tagged individuals at a stationary, continuously-recording antenna as they exited the reach altogether; (3) follow-up electrofishing on day 2 in the core area, as well as immediately upstream and downstream of the core area to detect PIT-tagged individuals that had moved outside of the core area between day 1 and day 2 (
Figure **5.3.2**). At one of the two sites where we applied the core sampling method (Westside Road), we did not install a PIT antenna and therefore we do not have an estimate of the number of fish that may have exited the reach altogether.

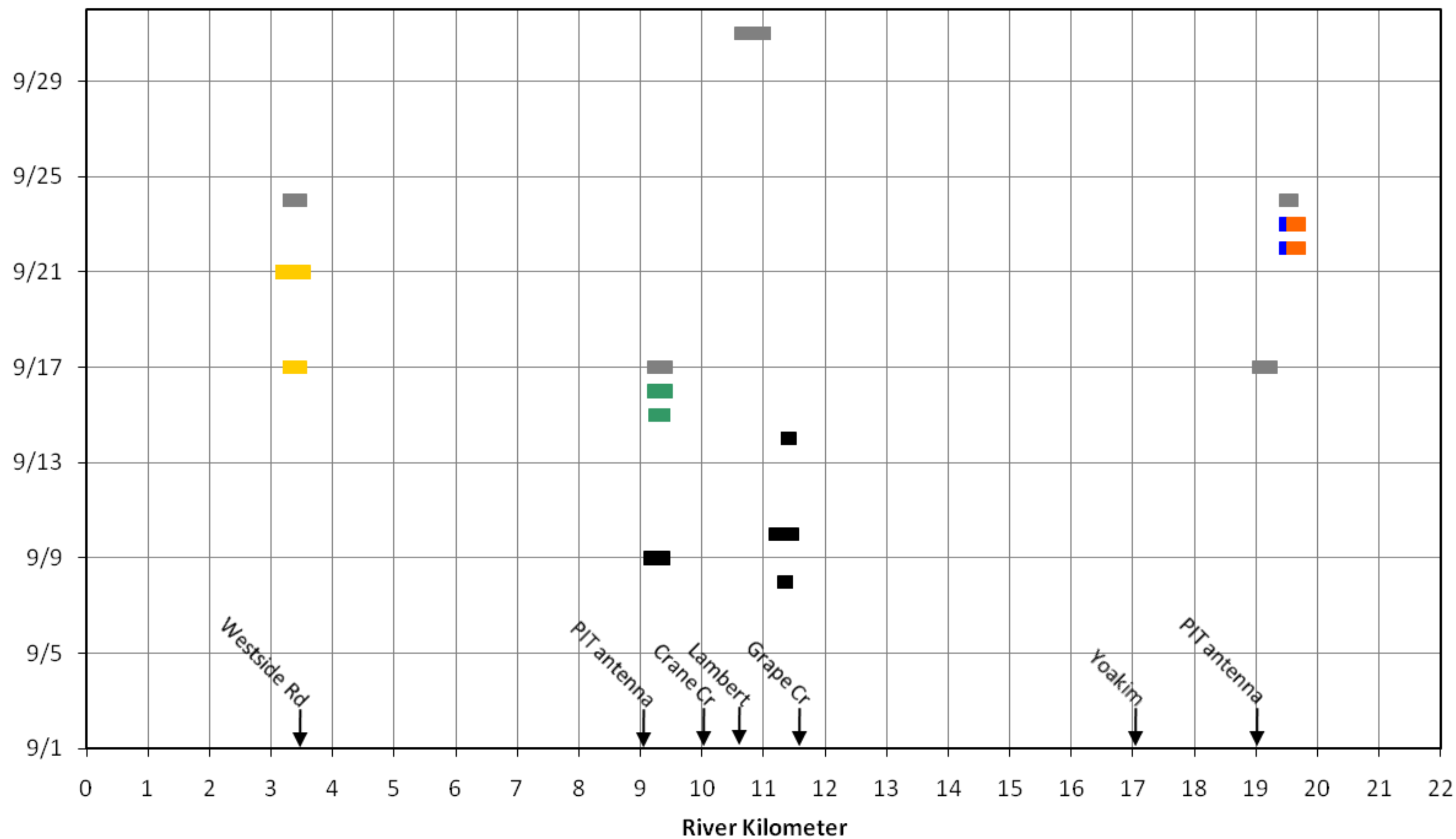
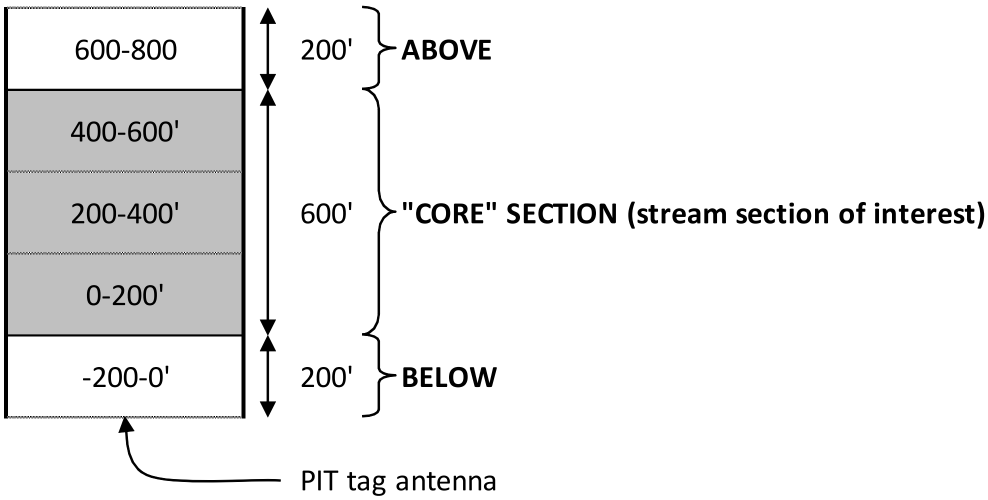


Figure 5.3.1. Sample dates and river kilometer (from the mouth) where fish populations were sampled in mainstem Dry Creek, 2009. Line length for each site is scaled to the length of stream sampled. Gray lines indicate sampling by snorkeling. Black and colored lines indicate sampling by electrofishing. Pairs of colored lines (yellow, green, red, blue) indicate day 1 (marking event) and day 2 (recapture event) of electrofishing sampling for mark-recapture (Petersen) estimates.



<u>Marking event (day 1):</u> Electrofished sections in **CORE** area and recorded fish locations by 200 foot sections. Returned fish to section of capture ($\pm$200 ft) after PIT-tagging all individuals $\geq$60 mm.

<u>Recapture event (day 2):</u> Sampled in **BELOW**, **CORE**, and **ABOVE** areas and recorded fish locations by 200 ft sections.

<u>Analysis:</u>

- ***Count movers***- Counted up fish that were recaptured **OUTSIDE** the core area (above and below) on day 2 that were originally captured **INSIDE** the core area on day 1
- ***Count emigrants***- Counted up fish that were detected on the antenna between day 1 and day 2
- ***Estimate core abundance***- Use Petersen estimator to estimate abundance for core area based on only the tagged fish that were tagged in the core area on day 1 and recaptured in the core area on day 2
- ***Adjustments to core abundance***
  - **Add movers**- Used the estimate of capture probability to expand the number of fish that moved out of the core area but did not emigrate downstream of the PIT tag antenna
  - **Add emigrants**- Used the estimate of detection probability to expand the number of fish that emigrated downstream of the PIT tag antenna

<u>Example (Beverly Hills)</u>

<u>Marking event (day 1):</u> Captured and tagged 156 individual steelhead in the "core" 600 foot section

<u>Recapture event (day 2):</u> Captured a total of 97 STHD, 27 of which were recaptures (17.1%)

<u>Analysis:</u>

- Captured a total of 3 tagged steelhead on day 2 outside of the core section (both had moved downstream, none were captured above); expansion of this number based on estimated capture probability from the Petersen model resulted in an estimate of 4 movers
- 6 fish from the core section were detected on the PIT antenna between day 1 and day 2; expansion of this number based on estimated antenna detection probability resulted in an estimate of 12 emigrants
- Petersen estimate based on 27 recaptures = 694 (95% CI: 511, 995)
- Petersen estimate based on 27+4+12 = 709 (95% CI: 527, 1010)

Figure 5.3.2. Description and example of core sampling method as applied to a site in Dry Creek.

To account for the differences in wetted area and facilitate comparisons among sites, we standardized abundance by calculating density (fish/m^2 of wetted area). To calculate wetted area for each section sampled, section length was multiplied by mean wetted width. Mean wetted width was estimated from a minimum of three measurements taken along the length of each 200 foot section. Other habitat attributes assessed included mean depth (estimated from multiple depths measured systematically throughout the section), maximum depth, habitat type (e.g., run, riffle) and amount and type and amount of in-stream fish cover.

Size

We measured the fork lengths of 1,024 juvenile steelhead including 824 individuals that we PIT tagged. We also measured fork lengths of juvenile steelhead captured in the rotary screw trap. That information is presented in the previous section of this report.

Habitat use, true survival, and growth

Although we did not directly evaluate methodologies that may be suitable for assessing habitat use, true survival, and growth metrics in 2009, we did begin to evaluate them in 2010. The results of those assessments will be discussed in the 2010 annual report.

Reach fidelity (residency)

On July 3, 3,200 PIT-tagged age-0+ steelhead reared at Warm Springs Hatchery were stocked in mainstem Dry Creek in two locations (river km 21.3 and river km 11.7). An equal number of fish (1,600) were stocked at each location. Prior to stocking, pairs of continuously recording PIT tag antennas were installed approximately 2.5 km downstream of each stocking location. Because antennas were paired, we were able to estimate efficiency as the proportion of fish that were detected on the downstream antenna in the pair that were also detected on the upstream antenna in the pair. Antenna detection efficiency was used to expand the observed number of detections at each antenna location to arrive at an estimate of the total number of emigrants from each reach.

Results

Abundance (density)

Electrofishing. Despite our best efforts to achieve geographic closure, our efforts failed (Figure 5.3.3). At both sites, portions of the mesh panels collapsed prior to completing the first pass. We experienced similar results in 2008 (Figure 5.3.3) (Water Agency 2008).

Snorkeling. In general, the number of fish captured during a single electrofishing pass was higher than the number of fish observed during a single snorkeling pass (Figure 5.3.6 upper panel); typically, however, the differences were not large. However, due the nature of the estimator used to estimate abundance for each method (bounded count for snorkeling vs. mark-recapture for electrofishing), the differences in terms of estimated abundance were quite a bit higher for electrofishing-based estimates than they were for snorkel-based estimates (Figure 5.3.6, lower panel).

(a) Before

(b) After

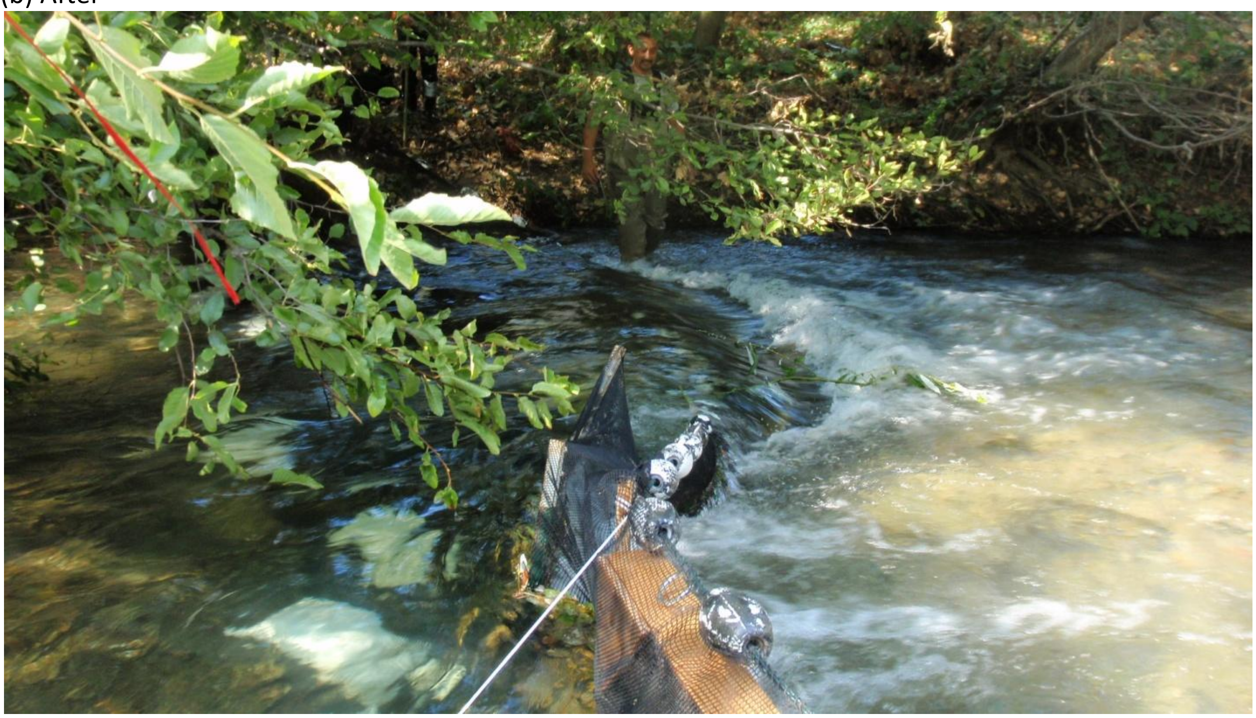


Figure 5.3.3. Mesh panels used to close stream sections during sampling for abundance estimates in mainstem Dry Creek before the commencement of sampling (a) and after 1/3 of a pass through the section (b). Average velocity was 1.46 fps and average water depth was 1.48 feet in the section.

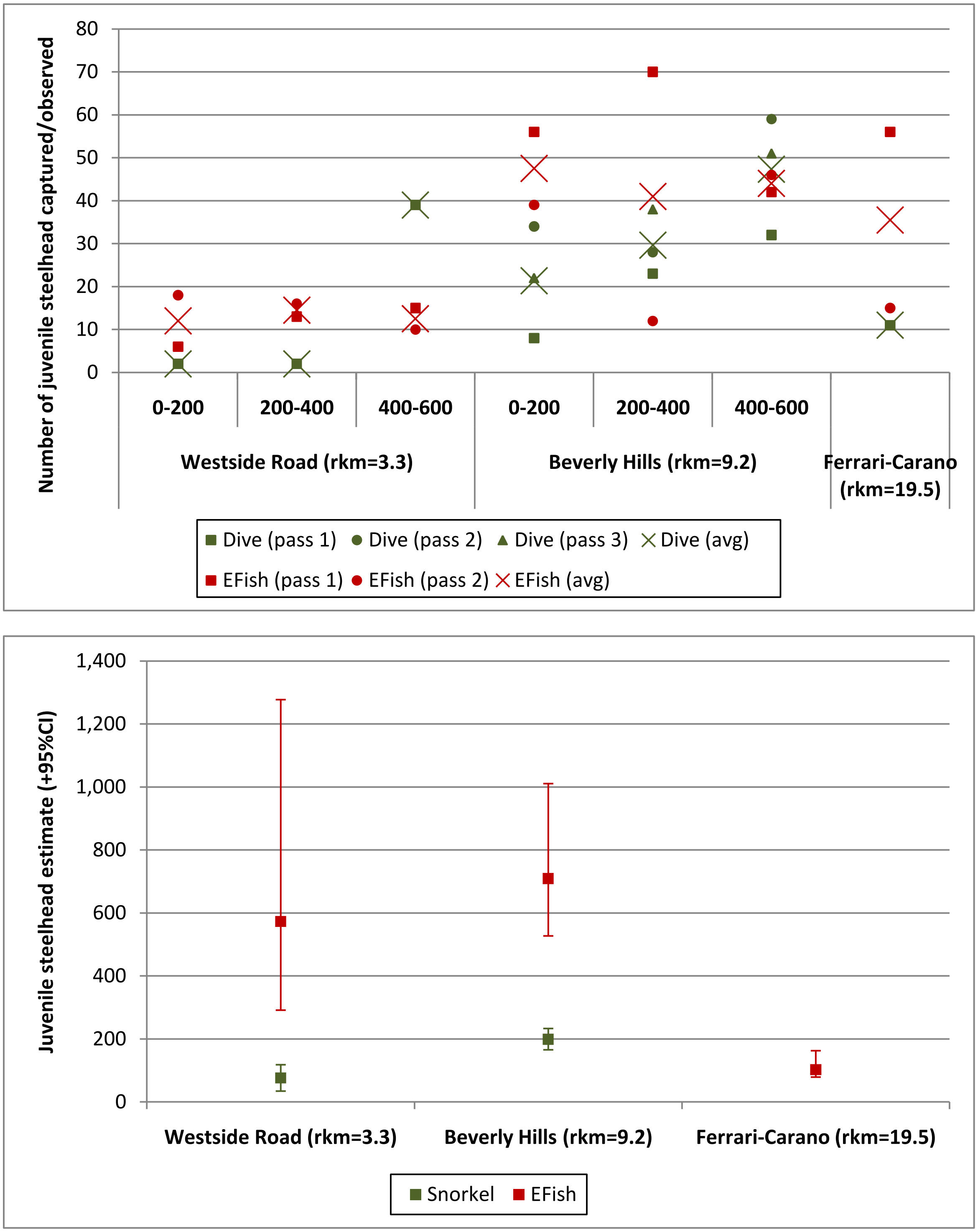


Figure 5.3.4. Comparison of the number of juvenile steelhead detected/captured by method and pass for multiple 200 foot (61 meter) sections in Dry Creek (top panel) and bounded count estimates (snorkeling) and Petersen estimates (electrofishing) (bottom panel), 2009. Note that only one snorkeling pass was conducted at the Ferrari-Carano site therefore no bounded count estimate was possible.

Petersen estimates and core areas.

The number of juvenile steelhead estimated to have exited the core area at the two sites where we conducted the core sampling was low (zero fish at Westside Road and four fish, 2.6%, at Beverly Hills). We estimate that 12 fish (8%) exited the Beverly Hills reach altogether (no antennas were used at the Westside Road reach). Based on this as well as the Petersen estimates from two other sites at Ferrari-Carano, we estimated juvenile steelhead densities to be in the range of 0.09-.24 fish/m^2 (Figure 5.3.5).

Size

There appeared to be a trend towards smaller-sized steelhead with increasing distance from the mouth of Dry Creek (Figure 5.3.6). Fish from the lower reach were especially large. This same trend was evident in data from 2008 as well (Water Agency 2009).

Reach fidelity (residency)

Antenna detection efficiency at the antenna site in the upper reach was 65% while it was 49% for the lower reach antenna site. Based on this, we estimate that 497 individuals (31%) exited the upper reach while 243 individuals (15%) exited the lower reach. Approximately 88% of the estimated emigration in each reach occurred during the 7 days following stocking (Figure 5.3.7).

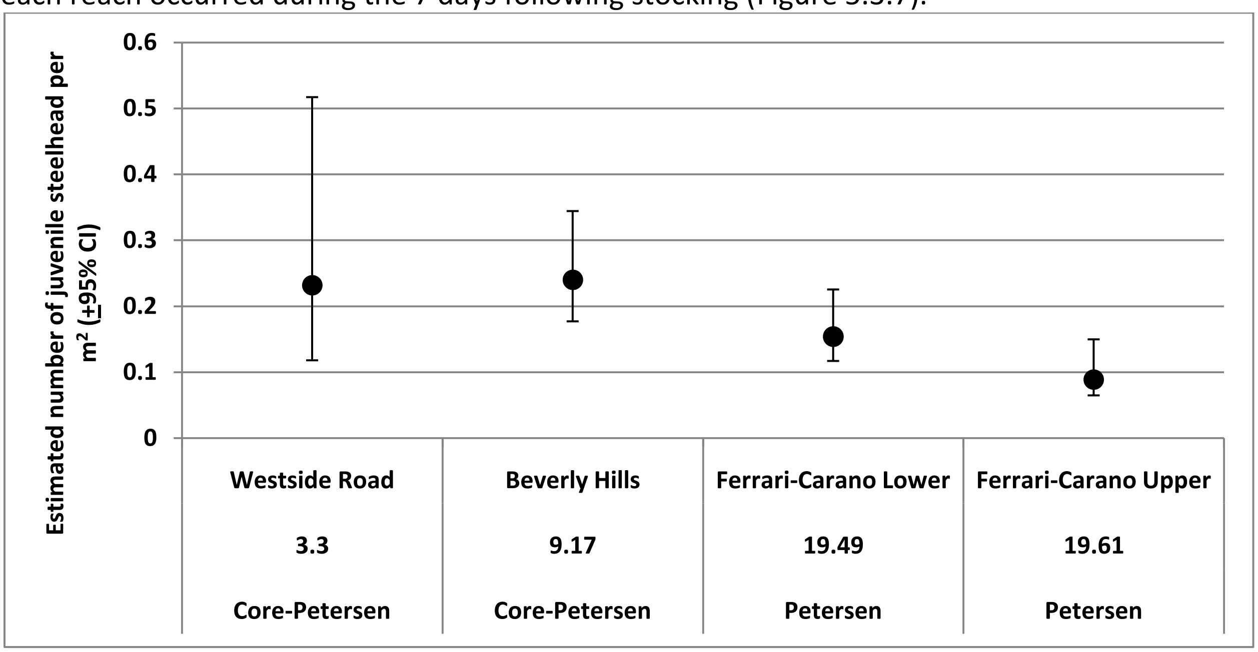


Figure 5.3.5. Estimated density of steelhead by site and river km, Dry Creek, 2009.

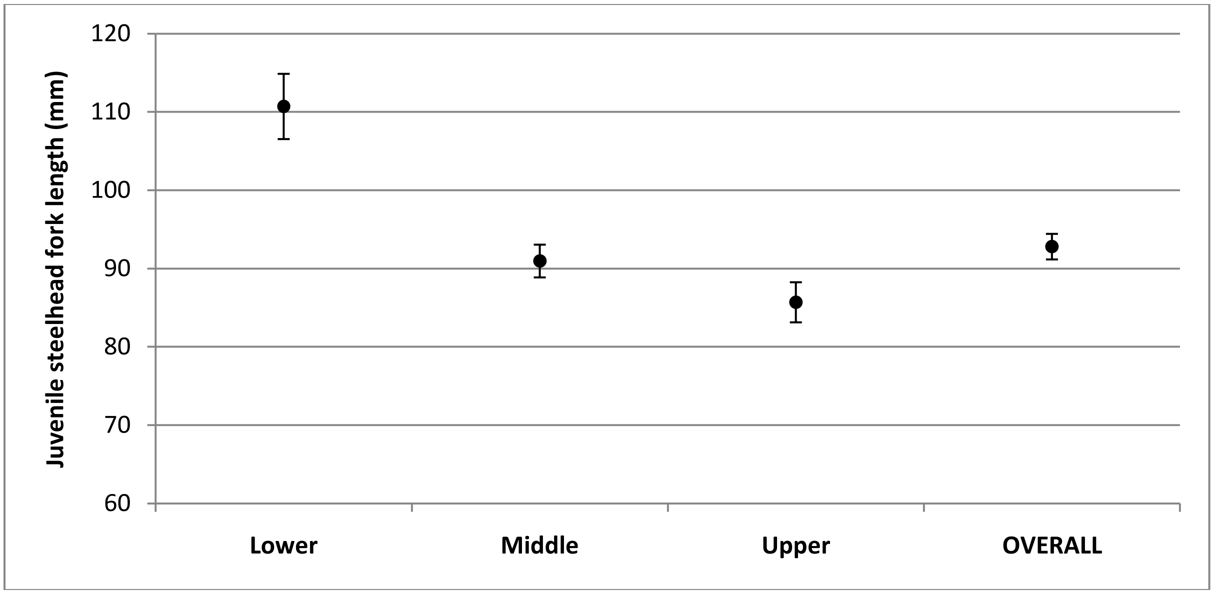


Figure 5.3.6. Sizes of juvenile steelhead captured by electrofishing in the each of three reaches of mainstem Dry Creek.

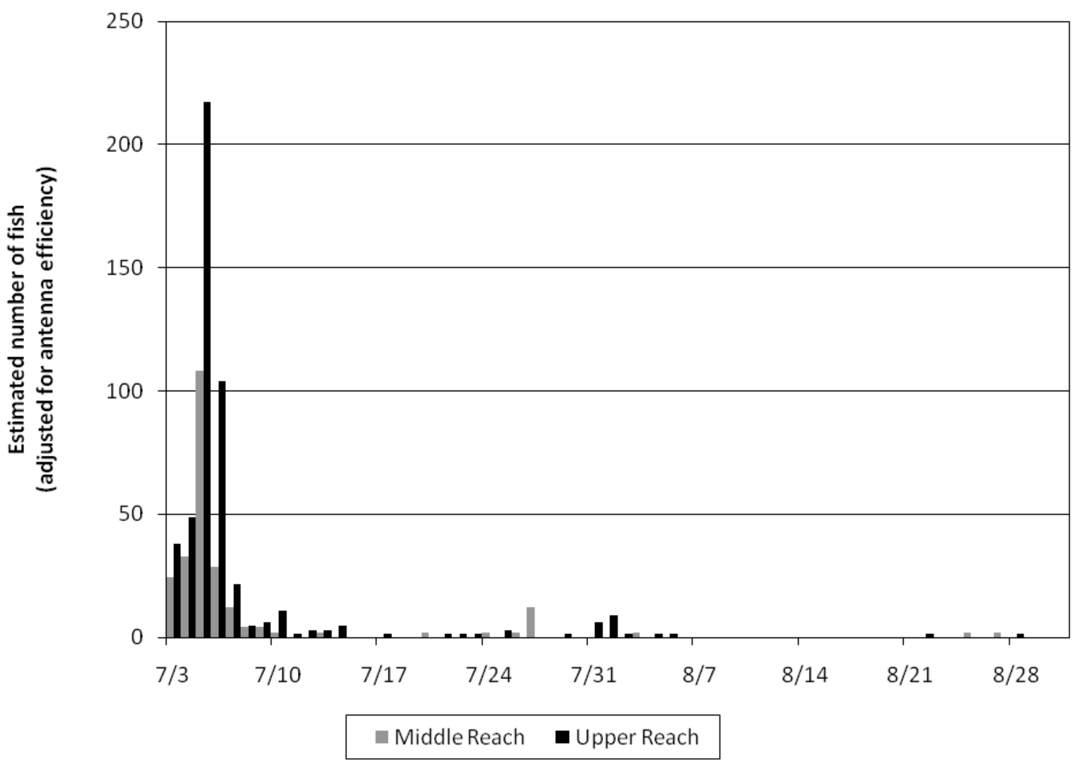


Figure 5.3.7. Estimated number of PIT-tagged fish emigrating from two reaches on Dry Creek. Estimates were made by expanding the number of fish detected at each antenna site by the estimated detection efficiency.

Conclusions and Recommendations

It is our intent that the monitoring plan we develop to evaluate the habitat enhancement work in Dry Creek maximize our ability to isolate the effects of treatment (i.e., habitat enhancement measures) as opposed to non-treatment variables. We expect that the two main issues confronting our ability to make that distinction will be related to temporal and spatial considerations. These issues could manifest themselves in our sampling design, the biological response or both. For example, the number of years of pre- and post-enhancement sampling will have a direct bearing on our ability to distinguish between background variability and treatment variables (see Wieckowski et al. 2010 and references therein for examples). Likewise, benefits to juvenile salmonids may not accrue immediately or they may not be measurable until later. In addition, the locations we choose to sample or are able to sample can affect the segment of the population we are using for inference thereby calling into question whether that segment is actually able to take advantage of the specific habitat enhancement we are attempting to validate. The following summarizes our evaluation of the population metrics considered and the relevant sampling methods in the context of these spatial and temporal concerns.

An important conclusion regarding the metrics we considered is that obtaining annual estimates of population density and body size distributions of stream-dwelling life stages of juvenile salmonids in late summer/early fall is quite feasible using backpack electrofishing gear but not by snorkeling observation. Further, we found that it is not possible to maintain geographic closure of stream sections in mainstem Dry Creek under typical summer flows long enough to conduct multiple-pass depletion sampling. We further qualify the utility of backpack electrofishing gear for depicting density and size by pointing out that this gear has been shown to be limited in deeper water and at higher water velocities. Given the current conditions in Dry Creek, these factors in particular should at the very least caution us when interpreting data collected using backpack electrofishing in many habitats currently found in Dry Creek. We anticipate that because habitat enhancement measures will be designed to increase habitat complexity and depth, the utility of backpack gear for estimating density will remain limited in the future because of increased pools depths and difficulty accessing fish that may be using newly added shelter material such as logs and root wads.

To address the concerns about the potential biases in density and size estimates from electrofishing gear, we consulted with NMFS near the end of the 2009 sampling season and settled on the core-sampling design described above (see Methods section). This approach provides the advantage of eliminating the need for maintaining physical barriers to achieve geographic closure and instead relies on a combination of sampling for PIT-tagged fish immediately above and below an area of interest and electronic detections at PIT-antenna “weirs” to adjust Petersen mark-recapture estimates. By employing this approach, we expect to significantly increase the time spent actually sampling the population as opposed to the set-up time involved with erecting and dismantling barriers at each site. The result was that we were able to significantly increase the amount of habitat sampled. We envision this approach as an integral part of an overall sampling plan for Dry Creek that includes estimating metrics other than just density. Despite the advantages, however, core sampling alone still does not allow us to overcome some of the biases inherent with backpack electrofishing gear described above. These gear limitations, in addition to the physical limitations of simply wading some sections of mainstem Dry Creek, mean that we must be selective in the types of habitat we sample and use care in interpreting the results. It also means that we may need to turn to alternative metrics to augment the density data we collect.

Moving forward, we see that metrics such as true survival, growth, and site fidelity may be important additions to estimates of density within and near newly-enhanced habitat features (Table 5.3.1). Snorkeling as well as PIT-tagging, stationary PIT antennas and PIT wands, could all prove to be useful approaches for validating habitat use and therefore the effectiveness of habitat enhancements on mainstem Dry Creek.

References

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White, G. C. and Burnham, K. P. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46: 120-139.

Wieckowski, K., M. Porter, D. Pickard, and D. Marmorek. 2010. Dry Creek Adaptive Management Framework (AMF). Report prepared by ESSA Technologies Ltd., Vancouver, BC for Sonoma Water County Agency, Santa Rosa CA (Draft prepared: September 15, 2010).

Table 5.3.1. Summary of metrics, methods and their applicability for validating eventual habitat enhancement measures in mainstem Dry Creek. Colored shading indicates the spatial scale at which metrics could be measured (tan: site; green: reach and/or stream).

Metric	Electrofishing		Snorkeling	PIT-wanding	PIT-tagging & stationary antennas
	Estimates in discrete sections	Alternative sampling			
Abundance (density)	**NO**- Requires geographic closure for depletion and Petersen but this is generally not possible in Dry Creek	**YES**- "Core" sampling may work with Petersen (potential to sample longer sections)	**NO**- Subject to bias	**NO**	**NO**
Size	**YES**	**YES**	**NO**	**NO**	**NO**
Habitat use	**YES** -Presence/ absence (or high, low, absent)- could be biased if applied at inappropriate spatial scale	**NO**	**YES** - Presence/ absence (or high, low, absent)	**MAYBE** - Would have to evaluate in Dry Creek	**YES** - e.g., placing antennas at the downstream end of side channels
True Survival	**NO**	**YES**- With PIT oversummer survival estimates possible	**NO**	**NO**	**YES**- With fall abundance oversummer survival estimates possible
Growth		**YES**- With PIT	**NO**	**NO**	**NO**
Residency (reach fidelity)	**NO**	**YES** - With PIT	**NO**	**NO**	**YES**

6: Tributary Habitat Enhancements

One component of the reasonable and prudent alternative (RPA) identified in the Biological Opinion is the enhancement of salmonid rearing habitats in tributaries to Dry Creek and the Russian River. A total of ten potential tributary enhancement projects are listed in the Biological Opinion with the requirement that the Water Agency implement at least five of these projects by the end of year 3 of the 15 year period covered by the Russian River Biological Opinion. The five projects that the Water Agency intends to complete are 1) Grape Creek Habitat Improvement Project; 2) Willow Creek Fish Passage Enhancement Project; 3) Grape Creek Fish Passage Project; 4) Wallace Creek Fish Passage Project; and 5) Mill Creek Fish Passage Improvement. A sixth project, the Crane Creek Fish Passage Access Project has been identified as an alternative project in the event that one of the five identified projects cannot be constructed. The Water Agency entered into an agreement with the Sotoyome Resource Conservation District on December 16, 2008 to coordinate and implement the Grape Creek Habitat Improvement Project, Mill Creek Fish Passage Project, and the Crane Creek Fish Passage Access Project. The Water Agency is coordinating with the County of Sonoma Department of Public Works and Permit and Resource Management Department on the design and implementation of the Grape Creek Fish Passage Project and the Wallace Creek Fish Passage Project. On October 19, 2009, the Water Agency's Board of Directors approved a funding agreement with Trout Unlimited authorizing the Water Agency to provide funding of $100,000 to Trout Unlimited towards the construction of the Willow Creek Fish Passage Enhancement Project.

Grape Creek Habitat Improvement

Phase 1

The Grape Creek Phase 1 portion of the project consisted of installing 8 complex log and boulder structures along a 1,200 foot reach of Grape Creek upstream of the Wine Creek Road Crossing (Figure 6.1). Implementation of this work took place in July and August of 2009. All areas where vegetation was disturbed by heavy equipment were replanted with native plants prescribed by restoration staff from the RCD. Additional plantings were also installed per the request of DFG, and permission of the landowner, in areas outside the active construction area in an effort to eventually expand the width of the riparian area. A total of 248 native trees and shrubs were planted along this reach of the project.

Figure 6.1. Grape Creek – Phase 1. In-Stream Large Woody Debris Structure Example

Phase 2

The Grape Creek Phase 2 portion of the project consisted of installing 9 complex log and boulder structures and 2 bank layback areas along a 700 foot reach of Grape Creek upstream of the West Dry Creek Road Crossing (Figure 6.2). Implementation of this work took place over two construction seasons, in 2009 and 2010. Construction began in early October 2009 and was cut short due to rain. Revegetation took place in January 2010. In February 2010, portions of one structure (Site 5) were removed as an emergency measure to avoid bank erosion on the opposite bank as a result of the structure's movement during high flows. Construction resumed in late August 2010, with heavy equipment work completed in the first week of September, and final touches placed on erosion control in early October. The remaining vegetation will be installed in late 2010/early 2011 when the soil is sufficiently moist.

Figure 6.2. Grape Creek – Phase 2. Large Woody Debris and Bank Layback Example.

Willow Creek Fish Passage Enhancement Project

Willow Creek is a tributary to the lower Russian River that once supported an abundant subpopulation of coho salmon. The creek continues to support significant potential spawning and rearing habitat; however, access to that habitat is blocked by impassable road culverts and a shallow braided channel that passes through forested wetland. To implement the Willow Creek Fish Passage Enhancement Project, the Water Agency has contributed $100,000 in funding to Trout Unlimited towards the removal of a complete barrier in Willow Creek. On October 19, 2010, the Water Agency's Board of Directors approved the funding agreement with Trout Unlimited for the Willow Creek Fish Passage Enhancement Project.   Attached in Appendix E-1 is a copy of a letter from the National Marine Fisheries Service describing the project and confirming that the provision of funds to Trout Unlimited constitutes completion of the Water Agency's obligation for implementing the Willow Creek Fish Passage Enhancement Project.

Grape Creek Fish Passage Project

The Grape Creek Fish Passage Project consists of the modification of a concrete box culvert where Grape Creek flows under West Dry Creek Road (Figure 6.3). The Water Agency is coordinating with Sonoma County Department of Public Works and Sonoma County Permit and Resources Management Department on finalizing the project designs and obtaining the necessary permits for construction. The Water Agency is awaiting permitting approval from CDFG and NMFS for the Grape Creek Fish Passage Project and construction is estimated to begin in early summer 2011.

Figure 6.3. Grape Creek Fish Passage Project – Flat culvert invert proposed for modification.

Wallace Creek Fish Passage Project

Wallace Creek Fish Passage Project consists of the modification of a concrete box culvert where Wallace Creek flows under Mill Creek Road (Figure 6.4). Engineering designs have been completed for the Wallace Creek Project. The County of Sonoma Permit and Resource Management Department is in the process of submitting permit applications and coordinating site visits with California Department of Fish and Game, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the North Coast Regional Water Quality Control Board. Construction is scheduled for summer and fall of 2011.

Figure 6.4. Wallace Creek Fish Passage Project – Flat culvert invert proposed for modification.

Mill Creek Fish Passage Project

Mill Creek Fish Passage Project consists of the removal of an old concrete flashboard dam base that is a significant barrier to migration for adult and juvenile coho and steelhead (Figure 6.5). The Water Agency is seeking landowner permission to design and implement a project to remove the passage barrier. On August 30, 2010, National Marine Fisheries Service sent a letter to the different landowners in the project area describing the value the Mill Creek Fish Passage Project has for contributing toward the recovery of Central California Coast coho salmon. Sotoyome RCD and NMFS are continuing efforts to obtain landowner agreements to move forward with the Mill Creek Fish Passage Project. As of November 2010, permission from a landowner that owns the property on one side of the project area has not been granted.

Figure 6.5. Mill Creek Fish Passage Project - Concrete Flashboard dam base.

Crane Creek Fish Passage Project

The Crane Creek Fish Passage Access Project remains a stanby project that can be implemented if the Water Agency is not able to implement one of the projects described above (Figure 6.6). The Crane Creek Fish Passage Access Project consists of the removal of a barrier to fish passgae caused by a bedrock outrcropping at the lower end of Crane Creek near its confluence with Dry Creek. The proposed project could consist of notching a larger pathway through the bedrock outcropping or creating a series of step pools to create sufficient depth and flow to allow fish passage.

Figure 6.6. Crane Creek Fish Passage Access Project. Bedrock outcropping.

7: Coho Salmon Broodstock Program Enhancement

The Biological Opinion and Consistency Determination require the Water Agency to increase production of smolts from the Russian River Coho Salmon Broodstock Hatchery Program (Coho Program). The Coho Program is located at the Don Clausen Fish Facility (Warm Springs Hatchery) at the base of Lake Sonoma on Dry Creek. Initiated in 2001, this innovate program is a multi-partner effort involving USACE, CDFG, NMFS, University of California Cooperative Extension (UCCE), Pacific States Marine Fish Commission (PSMFC), and the Water Agency. Native Russian River and neighboring Lagunitas (Olema) Creek stock are bred according to a genetic matrix and progeny are released to 13 streams in the Russian River watershed in spring as fry, in fall as fingerlings, and during winter and early spring as smolts. The Biological Opinion requires USACE to fund most hatchery operations and monitoring but also requires to the Water Agency to provide resources to DFG to produce 10,000 coho smolts for release directly to Dry Creek.

While negotiating the terms and form of the Consistency Determination in 2009, the Water Agency began discussions with DFG and USACE about hatchery program needs and the most effective method of providing resources. In late 2009 and early 2010, consensus was reached that the Water Agency would purchase 12 new rectangular start tanks and 3 circular tanks to be installed by USACE in 2010. In addition, the Water Agency will annually hire a technician to assist hatchery personnel.

In spring 2010, the Water Agency purchased 15 tanks for the Coho Program and they were installed by USACE in fall 2010. The Water Agency also hired a technician in spring 2010 and she began work full time at the hatchery in summer 2010. The current release plan for Coho Program smolts includes more than 10,000 fish for release into Dry Creek (Table 7.1).

Table 7.1. Russian River Coho Program 2010-11 planned smolt releases (B. White, PSMFC, personal communication).

Stream	# of Fish	Tagging Strategy	Comments
Mill Creek	5,966	Snout + Dorsal CWT (+ PIT)	All fish to be released into Mill Creek holding pond
Green Valley Creek	4,994	Snout + Dorsal CWT (+ PIT)	All fish to be released into GVC holding pond
Dutch Bill Creek	5,943	Snout + Dorsal CWT (+ PIT)	All fish to be released via DBC imprinting tank
Dry Creek	10,191	Snout CWT	All fish released directly into Dry Creek

8: Wohler-Mirabel Water Diversion Facility

The Water Agency diverts water from the Russian River to meet residential and municipal demands. Water is stored in Lake Sonoma and Lake Mendocino, and releases are made to meet downstream demands and minimum instream flow requirements. The Water Agency's water diversion facilities are located near Mirabel and Wohler Road in Forestville. The Water Agency operates six Ranney collector wells (large groundwater pumps) adjacent to the Russian River that extract water from the aquifer beneath the streambed. The ability of the Russian River aquifer to produce water is generally limited by the rate of recharge to the aquifer through the streambed. To augment this rate of recharge, the Water Agency has constructed several infiltration ponds. The Mirabel Inflatable Dam (Inflatable Dam) raises the water level and allows pumping to a series of canals that feed infiltration ponds located at the Mirabel facility. The backwater created by the Inflatable Dam also raises the upstream water level and submerges a larger streambed area along the river. Three collectors wells, including the Agency's newest and highest capacity well, are located upstream of Wohler Bridge. These wells benefit substantially from the backwater behind the Dam.

8.1 Mirabel Fish Screen and Ladder Replacement

To divert surface water from the forebay of Mirabel Dam, The Water Agency operates a pump station on the west bank of the river. The pump station is capable of withdrawing 100 cfs of surface flow through two rotating drum fish screens in the forebay. The fish screens have been functioning since the dam was constructed in the late 1970's. However, they fail to meet current velocity standards established by NMFS and DFG to protect juvenile fish. The Biological Opinion requires the Water Agency to replace the antiquated fish screens with a structure that meets modern screening criteria. In 2009, the Water Agency employed the engineering firm of Prunuske Chatham, Inc. to prepare a fish screen design feasibility study. The report was completed in December 2009 (Appendix F-1).

The feasibility study was conducted to develop a preferred conceptual design that meets many of the project objectives while ensuring that the fish screening facilities adhere to contemporary fish screening design criteria. A Technical Advisory Committee composed of the Sonoma County Water Agency, NMFS, and CDFG provided guidance in refining the objectives and identifying alternatives. Six concept alternatives were evaluated for meeting the project objectives. Schematic designs and critical details were developed for these concept alternatives to assess physical feasibility and evaluate alternatives relative to the objectives. The preferred concept design alternative was determined through an interactive evaluation and was selected because it meets or exceeds the project objectives.

The preferred concept design alternative includes a new intake with an inclined flat plate fish screen system, an oversized screen for increased bypass flow control and capacity, and a bypass fishway in the form of a vertical slot fish ladder. It also includes a fish viewing chamber with a window which will allow for real-time monitoring along with excellent education and outreach opportunities. The preferred conceptual design alternative will be a significant improvement for the water supply system and ecosystem protection. This alternative best meets the project objectives and is considered feasible for construction.

The estimated construction cost of the preferred conceptual design alternative is in the range of $3.5M to $4.0M. The construction cost estimate is not a total project cost. Other project costs will be considered in the next phase of project planning and design.

The next step of the project is to begin detailed environmental evaluation and engineering design of the preferred conceptual design alternative. In 2010, the Water Agency solicited qualifications from engineering firms and is currently preparing a request for proposals for the detailed engineering design to the most qualified firms. Because the fish ladder enhancement identified in the feasibility study is not required by the Biological Opinion, the Water Agency applied for funds from DFG’s Fishery Restoration Grant Program in 2010 to help defray costs associated with fish ladder design. The Director of DFG awarded the grant to the Water Agency in February 2011.

8.2 Wohler Infiltration Pond Decommissioning

The Wohler Infiltration Ponds 1 and 2 (originally built to assist with water supply operations) are located on the east side of the Russian River at the Water Agency’s Wohler facility. The Decommissioning Project is part of the Reasonable and Prudent Measure (RPM) 6 Terms and Conditions (Item C), in which the Water Agency is required to decommission or modify Infiltration Ponds 1 and 2 to prevent fish entrapment in the ponds during flood events.

The proposed project consists of decommissioning the off-channel Wohler Infiltration Ponds 1 and 2 by removal of two manual valves each located adjacent to the ponds and grading each pond at a slope of 1 percent toward the river. A 1% slope will allow the ponds to fill with water during flood events but will allow them to drain at the same rate as the receding river. The proposed project will prevent entrapment of salmonids in the ponds after flood events and will meet the requirements of the Biological Opinion. In addition, the Water Agency will perform periodic maintenance of each infiltration pond. The grade will be checked by Water Agency staff and will be re-graded as necessary in order to maintain the appropriate drainage.

The Water Agency has received all necessary state and federal agency permits to allow construction during the low-flow season (June 15- October 31, 2011), when the infiltration ponds are dry.

8.3 Mirabel Fisheries Monitoring

2009 marked the 10th year that fishery studies have been conducted at the Wohler-Mirabel site. Although this report details the findings of the 2009 sampling season, data from previous years will be included (where appropriate) to provide historical context. Fisheries studies at Mirabel Dam were developed in cooperation with the National Marine Fisheries Service and the California Department of Fish and Game to assess the potential for the dam to adversely impact listed species through: 1) altering water temperature and water quality in the lower river, 2) impeding downstream migration of juveniles, 3) impeding upstream migration of adults, and 4) altering habitat to favor predatory fish. The results of the initial 5-year study found that the dam likely resulted in an approximate 0.5°C increase in water temperature above what would have been expected without the dam in place (Chase *et al.* 2005), and that out-migrating juvenile steelhead experienced a short delay in passing the dam (Manning *et al.* 2007). Adult upstream migrating salmonids where not impeded by the dam (Chase *et al.* 2005). In addition, predator populations appeared to be balanced and large aggradations of predatory fish were not observed during August electrofishing surveys (Chase *et al.* 2005). The initial 5-year study concluded that the small increase in summer water temperatures were unlikely to impact salmonids since the average temperatures in the Wohler Pool were naturally in excess of 20.0°C, thus the Wohler Pool likely provides limited rearing habitat during the low flow summer months. Changes in the dam configuration (forming a V-notch to increase depth and velocity over the dam – see Manning *et al.* 2007 for details) significantly reduced the delay experienced by out-migrating steelhead smolts. Since 2005, the studies have focused on providing a long-term record of adult Chinook salmon escapement and juvenile salmonid emigration, as well as collecting basic life history information on all salmonids migrating past the Inflatable Dam.

Mirabel Downstream Migrant Trapping

The Water Agency has collected juvenile emigration data below the Inflatable Dam since 2000. Two rotary screw traps are generally fished below the dam from approximately April 1 through mid-July (depending on annual flow conditions). Data collected includes run timing, species composition, relative abundance, age, and size at emigration.

Methods

The rotary screw trap site is located approximately 60 m downstream of the Inflatable Dam. In 2009, two rotary screw traps (one 1.5-m diameter and one 2.5-m diameter) were operated. Overall, the date that the rotary screw traps were installed was

dependent on flow, and ranged from March 1 to May 4. In 2009, the traps were deployed on March 31 and fished through July 16. Fish captured by the screw traps were netted out of the live well and placed in an insulated ice chest supplied with freshwater. Aerators were operated to maintain DO levels in the ice chest. Prior to data collection, fish were transferred to a 19-liter bucket containing water and Alka-seltzer, which was used as an anesthetic. Fish captured were identified to species and measured to the nearest mm (FL). After data collection, fish were placed in a bucket containing fresh river water. Dissolved oxygen levels in the recovery buckets were also augmented with aerators to insure that the DO level remained near saturation. Once equilibrium was regained, the fish were released into the river downstream of the screw traps. In accordance with the Water Agency's NMFS Section 10 Research Permit, once water temperatures exceeded 21.1˚C, fish were not anesthetized, but were netted from the live well, identified, enumerated, and immediately released below the traps.
A mark-recapture study was initiated on April 7 and conducted through May 31 in an attempted to estimate the number of juvenile Chinook salmon that emigrated past the dam. As in previous years, we only marked juvenile Chinook salmon greater than 60 mm FL. Chinook salmon captured in the traps were sub sampled, and up to 50 fish daily (depending on the number of fish captured) were marked with a caudal clip. Marked fish were held in an ice chest equipped with aerators, and transported and released approximately 0.8 km above the Dam. The proportion of marked to unmarked fish captured in the traps was then used to calculate a weekly estimate of the number of Chinook smolts emigrating past the dam (Bjorkstedt 2000).

Results

In 2009, the two rotary screw traps were operated for 93 days (Table 8.3.1). A total of 28 species (15 native) including 3,736 (excluding larval Sacramento suckers, *Catostomus occidentalis*) individual fish were captured.

Table 8.3.1. Summary of Mirabel Dam rotary screw operations from 2000 to 2009.

Year	Deployment date	End date	Dam Inflated	Dates on non-operation	Days operated
2000	April 8	June 29	May 2	April 18, 19	82
2001	April 20	June 7	April 21	April 22 May 28, 29	46
2002	March 1	June 27	April 16	April 16	118
2003	March 1	July 3	May 23	March 15 – 19 April 13 – 21; April 24- May 11, 23	92
2004	April 1	July 1	April 8	April 8	91
2005	April 15	June 30	May 26	May 19-23; May 27 - 31	72
2006	May 4	May 24	May 11	May 12 - 15	18
2007	March 21	June 28	March 28	March 30 May 30	99
2008	March 20	June 26	April 11	April 11 – 13 May 17 – 18 June 10, 16,24	104
2009	April 1	July 17	July 8	April 15 May 5-7 July 2, 9, 14	93

Chinook salmon

A total of 1,399 juvenile Chinook salmon were captured in 2009. Although trapping conditions (suitable flows) were present throughout the majority of the sampling period, relatively few Chinook salmon were captured compared to previous years (Table 8.3.2). The low catch rate was likely related to poor trapping efficiency. Prior to 2009, overall trapping efficiency has ranged from 6.3 to 11.4 percent. In 2009 the trapping efficiency was 2.8 percent. There are two likely reasons for the poor catch rate which will be discussed in the conclusions section. The 2009 mark-recapture estimate of 41,663 juvenile Chinook salmon migrating past the trapping site was similar to 2003 and 2008, but far below the 2002, 2004, and 2007 estimates (Table 8.3.3).

The peak catch of juvenile Chinook salmon occurred between mid-April and mid-May, similar to previous years. The weekly average measured fork length for Chinook salmon captured below the Inflatable Dam ranged from approximately 55 mm in early April to approximately 85 mm in mid-June (Figure 8.3.1). The weekly average fork lengths of Chinook salmon measured in 2009 averaged 10 percent smaller compared to previous years

Table 8.3.2. Weekly catch of juvenile Chinook salmon at the Mirabel Dam trapping site, 2000 – 2009.

Week	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
26-Feb			45	332						
5-Mar			74	841						
12-Mar			319	89						
19-Mar			181	169				257	114	
26-Mar			797	346				940	80	6
2-Apr	41		908	377	82			730	224	257
9-Apr	158		757	176	115	446		564	100	236
16-Apr	154	122	2279	17	672	848		1011	866	190
23-Apr	204	720	2992	60	1911	618		759	1161	159
30-Apr	169	1338	4337	0	1845	353		1148	315	67
7-May	121	1154	1780	50	1631	132	69	782	258	149
14-May	174	226	2056	508	552	222	46	880	381	123
21-May	106	76	1755	690	158	35	217	698	91	55
28-May	92	64	704	1461	150	419	67	503	107	64
4-Jun	66	22	192	530	125	541		857	60	42
11-Jun	47		93	374	31	136		268	94	30
18-Jun	19		46	186	88	156		45	19	9
25-Jun	10		4	86	26	55		38	8	2
2-Jul				3						8
9-Jul										1
16-Jul										1
Total	**1,361**	**3,722**	**19,319**	**6,295**	**7,386**	**3,961**	**399**	**9,480**	**3,878**	**1,399**

Table 8.3.3. Estimated number of juvenile Chinook salmon that passed the Mirabel Dam site, based on mark-recapture trap efficiency testing, from 2001 to 2009.

Year	Number marked	Number recaptured	Overall efficiency	Seasonal estimate[1]	95% CI
2000	N/A	N/A	N/A	N/A	N/A
2001	525	60	11.4	19,473	5,022
2002	2,778	253	9.1	225,135	37,028
2003	1,072	90	8.4	45,699	18,218
2004	1,631	120	7.4	91,352	17,652
2005	N/A	N/A	N/A	N/A	N/A
2006	N/A	N/A	N/A	N/A	N/A
2007	3,201	203	6.3	149,329	28,722
2008	1,321	88	6.7	43,774	16,768
2009	709	20	2.8	41,663	10,208

[1]Includes fish captured outside of the mark-recapture study period

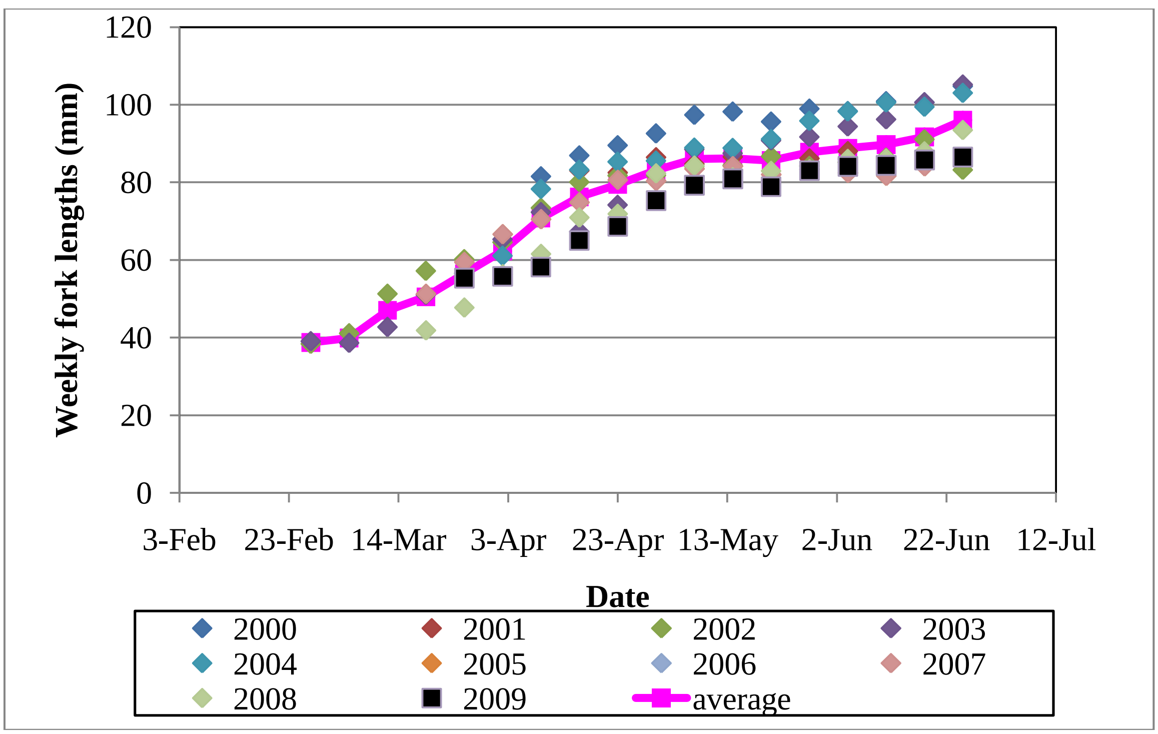


Figure 8.3.1. Weekly average fork lengths of Chinook salmon smolts measured at the Mirabel Dam trap site in 2009 (pink line) compared to years 2000-2008.

Steelhead

Juvenile steelhead were captured between April 3 and July 6 in 2009. For the season, 74 wild (natural origin) steelhead parr were captured, 72 of which were likely YOY based on length-frequency data (Figure 8.3.2, Table 8.3.4). In addition, 33 steelhead smolts were captured in 2009. This total tied 2008 for the lowest number of smolts captured in any year sampled (excluding 2006 when sampling was limited by high streamflow) (Table 8.3.5). Based on captures at the Mirabel fish trapping station, the steelhead migration season runs from at least March through June, with peak numbers occurring between mid-March and mid-May. Steelhead smolts ranged in length from 140 to 239 mm FL and averaged 171 mm FL. Since 2000, the average size of steelhead smolts has ranged from 161 to 185 mm FL.

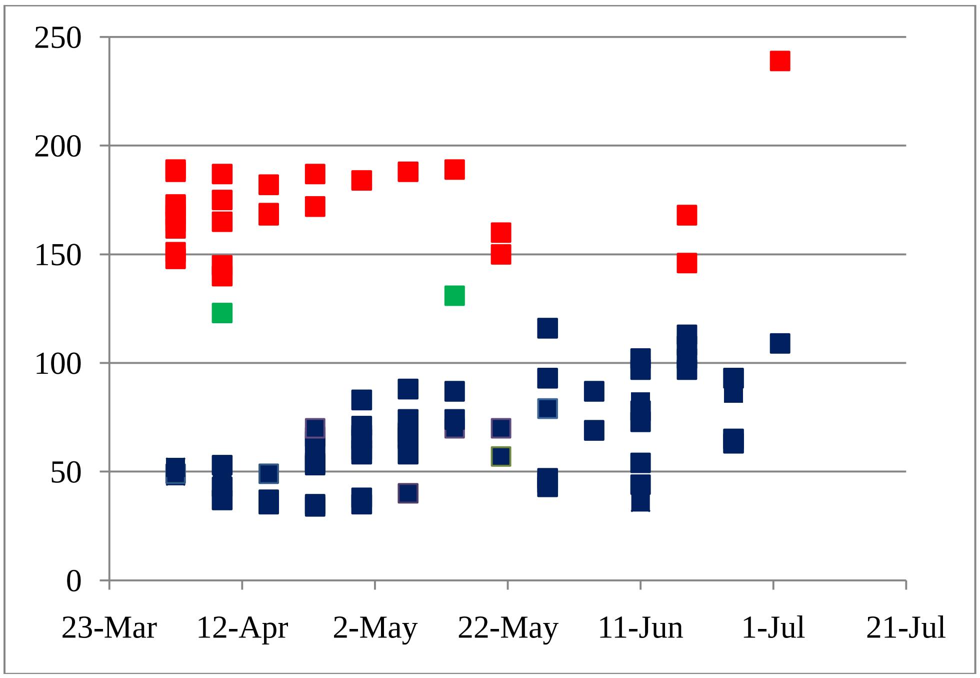


Figure 8.3.2. Length of steelhead captured in 2009, grouped by week of capture. Blue squares represent young-of-the-year (age 0+), green squares represent parr (age 1+), and red squares represent smolts (age 1-2+).

Table 8.3.4. Weekly catch of steelhead young-of the year (age 0+) and parr (age 1+) at the Mirabel Dam trapping site, 2000 – 2009.

Week	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
26-Feb	0	0	0	1	0	0	0	0	0	0
5-Mar	0	0	0	5	0	0	0	0	0	0
12-Mar	0	0	1	3	0	0	0	0	0	0
19-Mar	0	0	8	13	0	0	0	1	1	0
26-Mar	0	0	3	67	0	0	0	27	7	0
2-Apr	0	0	56	170	3	0	0	8	14	4
9-Apr	3	0	51	132	14	86	0	12	35	4
16-Apr	20	1	447	4	12	100	0	39	34	4
23-Apr	33	17	81	20	16	97	0	136	74	8
30-Apr	224	4	658	0	10	523	14	58	118	11
7-May	30	13	756	22	3	354	12	164	133	7
14-May	49	23	976	74	1	75	182	157	52	3
21-May	80	34	1315	246	1	25	26	185	101	8
28-May	74	32	806	223	2	110	0	173	59	6
4-Jun	102	26	467	55	2	136	0	684	76	2
11-Jun	40	0	164	29	1	40	0	176	50	8
18-Jun	58	0	60	28	10	29	0	5	26	4
25-Jun	50	0	1	2	7	9	0	22	10	4
2-Jul	0	0	0	1	0	0	0	0	0	1
9-Jul	0	0	0	0	0	0	0	0	0	0
16-Jul	0	0	0	0	0	0	0	0	0	0
23-Jul	0	0	0	0	0	0	0	0	0	0
Total	**763**	**150**	**5,850**	**1,095**	**82**	**1,584**	**234**	**1,847**	**790**	**74**

Table 8.3.5. Weekly catch of steelhead smolts at the Mirabel trapping site, 2000 – 2009.

Week	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
26-Feb			1	4						
5-Mar			1	3						
12-Mar			38	5						
19-Mar			15	3				24	0	
26-Mar			24	39				99	1	
2-Apr			31	39	3			24	3	12
9-Apr	19		33	18	14	0		25	0	5
16-Apr	24	7	30		11	18		43	4	5
23-Apr	24	16	23		14	9		61	8	2
30-Apr	21	16	23		10	7	9	14	12	1
7-May	8	9	7		3	3	10	17	4	1
14-May	14	4	9	26	1	1	5	11	0	2
21-May	9	0	9	16	1	3	6	3	1	2
28-May	6	0	3	6	1	0		2	0	0
4-Jun	1	1	0	2	2	3		1	0	0
11-Jun	4		1	1	1	2		0	0	0
18-Jun	2		0	0	2	1		0	0	2
25-Jun	2		0	0	0	1		0	0	0
2-Jul										1
9-Jul										0
16-Jul										0
23-Jul										0
Total	**134**	**53**	**248**	**162**	**63**	**48**	**30**	**324**	**33**	**33**

Coho salmon

Coho smolts were captured between April 1 (first day of sampling) and June 14. For the season, 213 coho salmon smolts were captured (206 hatchery and 7 wild smolts) (Table 8.3.6). In 2009, hatchery coho smolts were captured in relatively high numbers from April 1 through mid-May. Hatchery coho smolts ranged in length from 93 to 161 mm FL. Weekly average lengths ranged from 119 (first week of sampling) to 125 mm FL (week of June 4), although there was no trend in coho smolt size throughout the run (Figure 3). Overall, for the 2009 trapping season, coho salmon smolts average 117 mm FL.

Table 8.3.6. Weekly catch of coho salmon smolts at the Mirabel Dam trapping site, 2006 – 2009. Most fish were marked from the Russian River Coho Salmon Hatchery Broodstock Program.

Week	2006	2007	2008	2009
26-Feb				
5-Mar				
12-Mar				
19-Mar		3	1	
26-Mar		1	6	4
2-Apr		0	6	23
9-Apr		2	2	35
16-Apr		9	10	38
23-Apr		8	16	33
30-Apr	1	15	17	3
7-May	1	38	23	26
14-May	1	24	9	23
21-May	0	7	1	9
28-May		1	0	7
4-Jun		0	0	1
11-Jun		0	0	4
18-Jun		0	0	0
25-Jun		0	0	0
2-Jul				0
9-Jul				0
16-Jul				0
Total	**3**	**108**	**91**	**206**

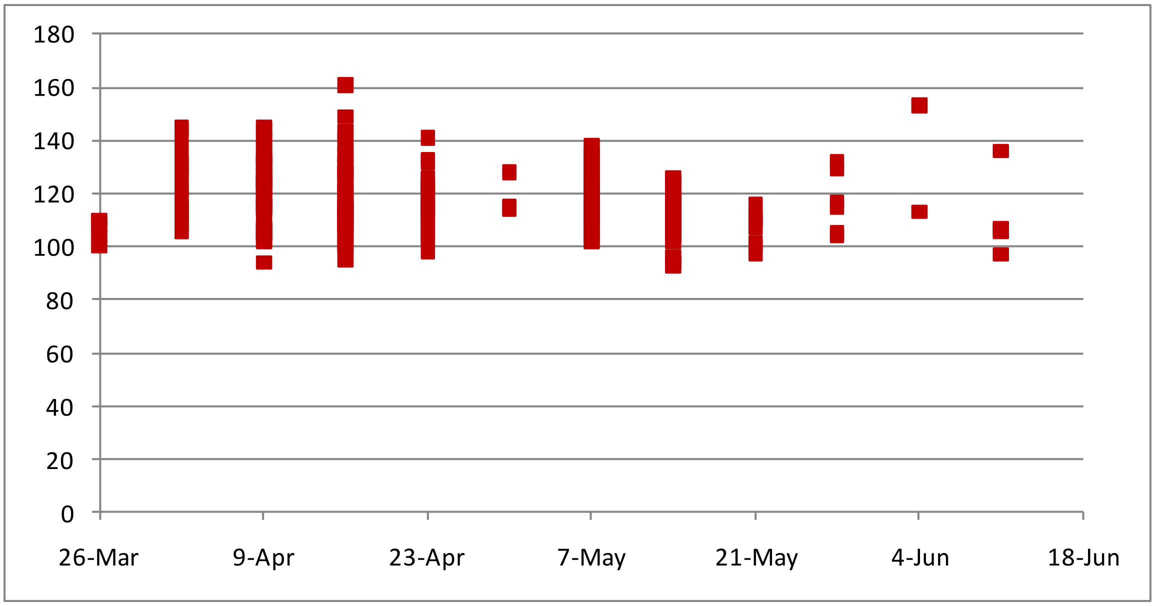


Figure 8.3.3. Coho salmon lengths captured in 2009, grouped by week of capture.

Conclusions and Recommendations

The overall capture of all species in the rotary screw traps at Mirabel was substantially reduced in 2009 compared to previous years. In addition, the capture efficiency of marked Chinook salmon was the lowest observed during the study period (2.8 percent in 2009 compared to 6.3 to 11.4 percent in previous years sampled). The configuration of the river channel below the Dam site and inflation of the Dam during the trapping season likely explain the decrease in trap efficiency during 2009. During the winter of 2000/01, a large mid channel gravel bar formed downstream of the dam. Vegetation has subsequently developed on the bar and it now functions as an island in the center of the channel. The island causes the river to split into two primary currents flowing past the trapping site. The current along the east bank flowed through a relatively narrow gap that could almost entirely be sampled with the 2.5-m screw trap. Streamflow moving down the west side of the river was deflected from the center of the river to the shoreline. The 1.5-m trap was positioned in the center of this current. The Dam, particularly when the v-notch is in place, also appears to concentrate the fish as they pass over it. The combination of the notched dam and the focused downstream currents likely concentrated fish and led to improved capture efficiencies for all species. In 2009, the Inflatable Dam was not installed until after the end of the outmigration season. In addition, in 2009 the mid channel gravel bar increased in size to the point where the majority of the flow was deflected to the west side of the river where the smaller of the two traps has traditionally been fished. The decrease in flow along the east bank also resulted in less scour and lower current velocities which further limited the efficiency of the 2.5-m trap. These conditions, in combination, likely resulted in a decrease in trapping efficiency and a reduction in the capture of all species.

This project is an essential component of the overall Russian River fisheries monitoring program and provides valuable information necessary for the management of all three listed species. Information collected at the Wohler trapping site provides long term trends in smolt emigration past the Wohler-Mirabel facility, as well as insights into their life history strategies. The 2.5-m and 1.5-m traps were switched at the end of the 2010 sampling season. We will continue to fish the 2.5-m trap on the west side and the 1.5-m trap on the east side to test whether trap efficiency is affected by trap placement. Further, we recommend that the dam be inflated with the notch in place to concentrate fish above the trapping site and provide efficient passage for downstream migrants.

Mirabel Fish Ladder Video Monitoring

The Inflatable Dam is approximately 4.0-m high, 45-m wide, and when fully inflated forms a barrier to upstream migrating fish. To provide upstream passage, the dam is equipped with two Denil-type fish ladders. The dam is typically inflated from early spring through late fall, depending on water demand and streamflow. The dam is typically inflated during the majority of the Chinook salmon migration period, and in years with low fall streamflow may remain inflated during the beginning of the coho salmon and steelhead migration periods.

The video counting system has been in operation at the Inflatable Dam since 2000. The original objective of this study was to verify that anadromous fish were able to ascend the fish ladders that provide passage around the dam. A secondary objective assessed the timing of migration and relative numbers of anadromous fish utilizing the fish ladders while the dam was inflated. Since the results of the original 5-year study demonstrated that anadromous fish were able to ascend the fish ladders, the counting stations has been operated primarily to document Chinook salmon escapement. The vast majority of spawning habitat lies above the dam; therefore, the counting station provides a good estimate of the overall run in the Russian River. However, during periods of high turbidity (generally associated with high streamflow), the cameras are ineffective and some portion of the run cannot be counted. As a result, the numbers presented here should be viewed as minimum estimates. Data collected at this station provide the only long-term estimate of Chinook salmon escapement along the central coast of California.

Methods

Passage of adult salmonids through the fish ladders was assessed using both analog VHS and digital underwater video cameras between 2000 and 2009 (Figure 8.3.4). The video systems utilized at the fish ladders were designed specifically for this project. The system used from 2000-2006 consisted of two ultra-high resolution monochrome video cameras with wide angle (105°) lenses housed in waterproof cases. The methods detailing the original system utilizing VHS time-lapse video technology is presented in Chase et al. (2005). In 2007 the camera system was upgraded to Axis 221 IP color digital surveillance cameras housed in custom built waterproof housings. Video was recorded onto a dedicated Server hard drive in a building adjacent to the Inflatable Dam. The footage was transferred to portable hard drives and brought back to the office where it was viewed on a computer. In 2008 the software was reconfigured to allow remote monitoring, archiving, and administration from the office. This added some redundancy to data storage and eliminated the need to retrieve data from the Mirabel site on a daily basis. A new waterproof high-intensity LED lighting system was employed in the 2009 season to improve night time recording. Additional fine tuning and system configuration was implemented to improve frame rates and picture quality. Fish were only counted moving upstream if they exited the upstream end of the ladder exit box. For each adult salmonid observed, the reviewer recorded the species (when possible), date, and time of passage out of the ladder. During periods of low visibility, it was not always possible to identify fish to species, although identification to family (e.g., Salmonidae) was often possible, and such fish were lumped into a general category termed "salmonid." Once viewed the video footage was copied to 4 or 8 GB DVDs for archival purposes.

Results

In 2009, the cameras were in operations almost continuously from August 15 to December 14, when the dam was deflated due to high flows. Since 2000, the cameras have been operated from August 1 through January 10, depending on annual flow conditions (Table 8.3.7). The image quality of the videos was generally good to excellent, producing images of sufficient quality to identify and count the majority of the fish passing through the fish ladder (Figure 8.3.4). Video monitoring demonstrated that adult Chinook, coho, steelhead, Pacific lamprey, and at least some American shad, are able to locate and ascend the Mirabel fish passage facilities. Detailed counts were made of adult anadromous fish only.

Figure 8.3.4. Video images of adult Chinook salmon passing through the exit box at the upper end of the Mirabel fish ladders. Image quality improved dramatically with the installation of the digital camera. The upper image was taken with ultra-high resolution monochrome video cameras while the lower image was taken with the new digital video system.

Table 8.3.7. Deployment and removal dates for the Mirabel underwater video system, 2000 – 2009.

Year	Date Deployed	Date Removed
2000	May 12	January 10 (2001)
2001	August 7	November 13
2002	August 12	December 11
2003	September 3	December 2
2004	August 1	December 8
2005	August 1	December 1
2006	August 14	November 26
2007	April 1	June 27
2007	August 17	December 15
2008	August 15	December 22
2009	August 15	December 16

Unknown Salmonids

Fish that were identified as a salmonid, but could not be identified to species were partitioned into Chinook or steelhead in an attempt to better estimate the number of each of these species observed in the fish ladders. Salmonids were partitioned by taking the proportion of Chinook salmon to steelhead positively identified to species in the ladder each day, and multiplying the number of salmonids by these proportions. In days where no salmonids could be identified to species an average ratio from adjacent days was used to categorize the unidentified salmonids (Table 8). This process was made easier by the fact that the Chinook and steelhead runs only minimally overlap. In 2009, 122 fish were categorized as an "unknown salmonid." Of the 122 fish, 100 were categorized as Chinook salmon, and 22 were estimated to be steelhead.

Table 8.3.8. The number fish classified as an unknown salmonids per year and their categorization as Chinook and steelhead.

Return year	Unknown salmonid	Estimated Chinook	Estimated steelhead
2005	42	41	1
2006	28	27	1
2007	156	99	57
2008	72	67	5
2009	122	100	22

Chinook

The number of adult Chinook salmon counted each year has ranged from 1,125 to 6,103 from 2000 through 2009 (Table 8.3.9). The date that the first Chinook salmon was observed during video monitoring ranged from August 20 to October 7. Few fish were observed prior to late September in any year sampled. Based on video monitoring, the typical Chinook salmon run in the Russian River begins in mid-September, peaks between the last week of October and mid-November, and ends in late December (Figure 8.3.5).

Table 8.3.9. Weekly count of adult Chinook salmon at the Mirabel Dam fish ladders, 2000 – 2009. Dashes indicate that no sampling occurred during that week.

Week	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1-Aug	0	0	0	--	0	0	-	-	-	-
8-Aug	0	0	0	--	0	0	-	-	-	-
15-Aug	0	0	1	--	0	0	0	0	0	0
22-Aug	1	0	8	--	0	1	0	0	0	0
29-Aug	0	3	7	2	1	2	0	0	1	0
5-Sep	9	1	18	7	1	5	0	0	0	0
12-Sep	38	7	19	20	3	11	2	0	1	0
19-Sep	23	12	65	23	8	13	3	0	14	0
26-Sep	50	17	1,223	181	16	20	7	1	65	0
3-Oct	31	240	113	146	42	34	120	7	122	21
10-Oct	115	51	628	515	51	114	255	38	109	394
17-Oct	81	10	272	232	585	403	531	28	11	362
24-Oct	466	300	153	532	2284	332	83	87	21	305
31-Oct	63	661	505	2969	183	632	1169	250	243	75
7-Nov	24	81	2,337	1289	1164	735	696	115	427	217
14-Nov	182	--	20	47	217	172	472	475	13	229
21 Nov	200	--	37	95	57	91	53	60	24	63
28 Nov	111	--	14	45	59	40	18	105	15	84
5-Dec	19	--	54	--	15	0	-	770	21	20
12-Dec	14	--	--	--	--	-	-	22	8	31
19-Dec	17	--	--	--	--	-	-	0	13	0
26-Dec	1	--	--	--	--	-	-	-	-	0
2-Jan	0	--	--	--	--	-	-	-	-	-
Total	**1,445**	**1,383**	**5,474**	**6,103**	**4,788**	**2,572**	**3,410**	**1,963**	**1,125**	**1,801**

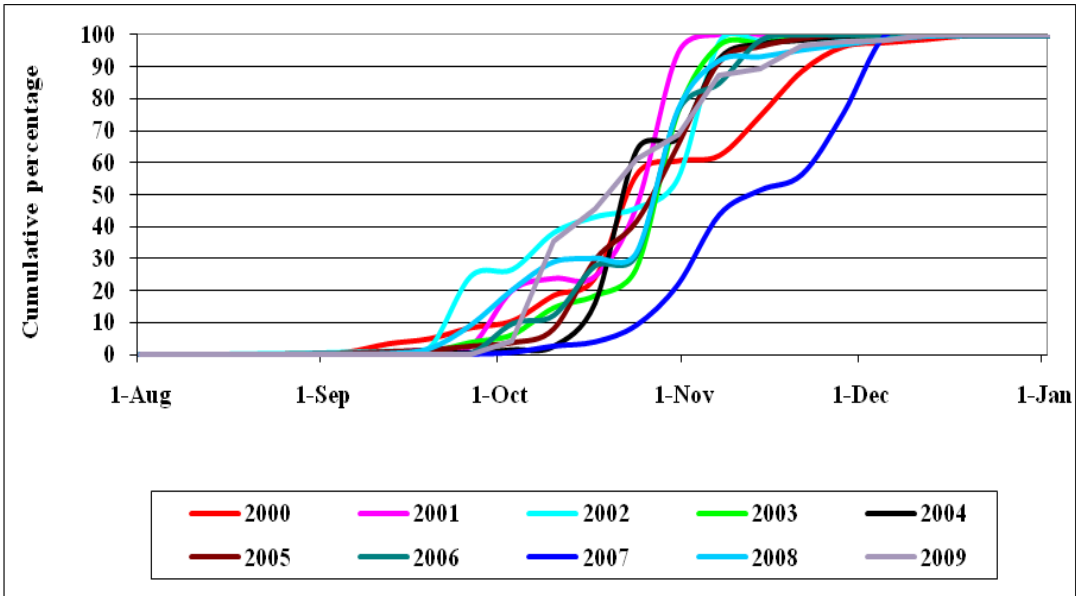


Figure 8.3.5. Cumulative percentage of the total number of adult Chinook salmon counted at the Mirabel Dam fish ladders each year from 2000 to 2009.

Pulses of Chinook salmon seen at the Wohler video monitoring station in 2009 often coincided with rain and barrier beach breaching events (Figures 8.3.6 and 8.3.7). These patterns were also observed in previous years. In early September of 2009, before the start of the Chinook migration, a barrier beach formed at the mouth of the Russian River blocking Chinook from entering the river (see Estuary Management chapter of this report). The river mouth remained closed until October 5, 2009 when the Agency intentionally breached the barrier beach to avoid flooding properties adjacent to the estuary. No Chinook were observed on the camera system prior to the breaching event. The first Chinook observed on the Wohler camera system in 2009 was seen 40.5 hours after the sand bar was breached and a total of 21 Chinook were observed in the next 24 hours.

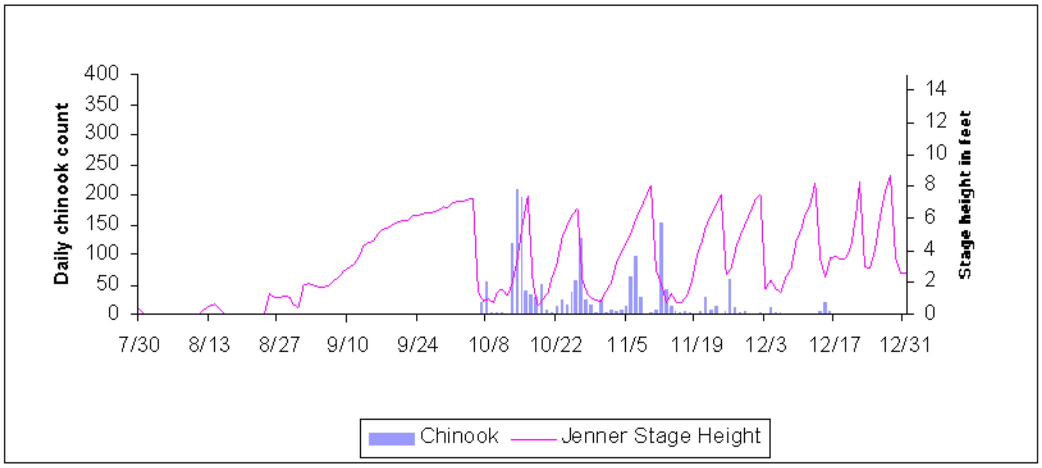


Figure 8.3.6. Daily Chinook salmon counts shown with the water surface elevation recorded at the Jenner gauge, 2009. High water surface elevations indicate that the mouth of the estuary is closed; low water surface elevations indicate the mouth of the estuary is opened (i.e., adult Chinook salmon have access to the Russian River from the ocean).

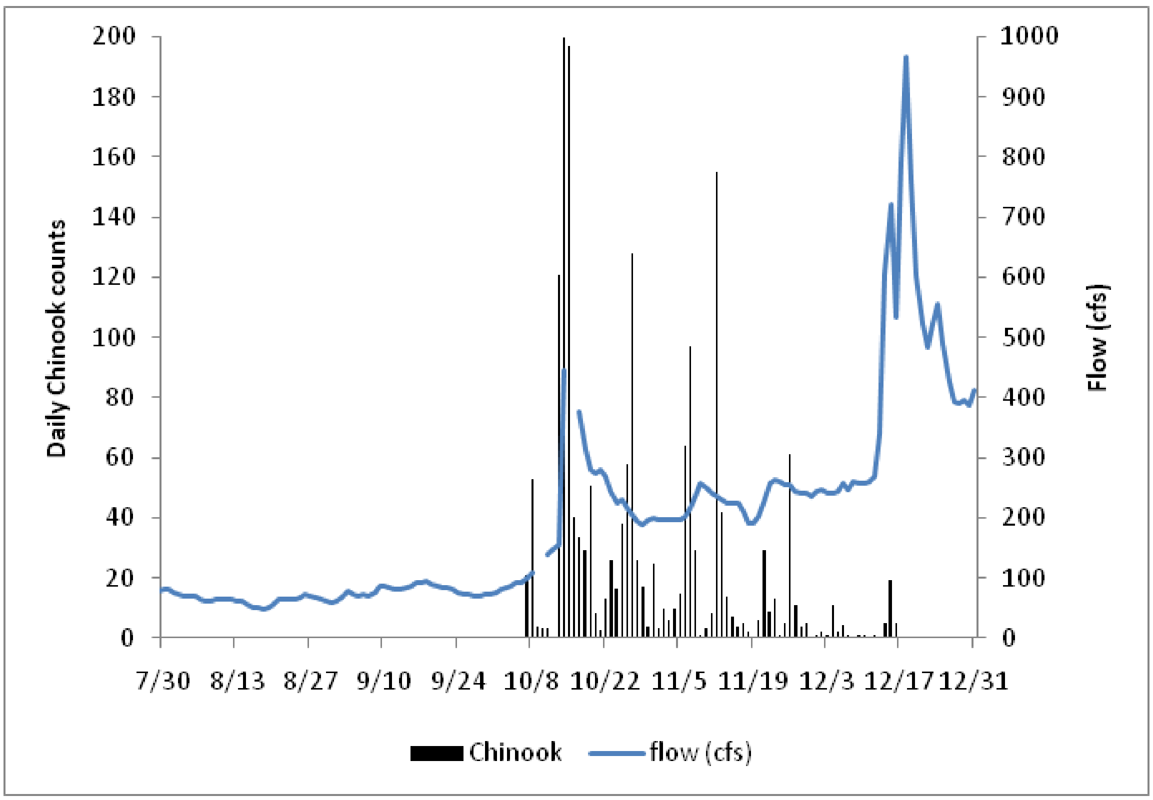


Figure 8.3.7. Daily Chinook salmon observations in 2009 at Mirabel Dam (bars) and Russian River flow (blue line) measured at the USGS Hacienda Bridge gaging station.

Coho

In 2009, six coho salmon were identified on the video system. These images were reviewed by multiple fisheries biologist from the Water Agency, NMFS, and University of

California Cooperative Extension (UCCE) to verify identification. The coho observed on the video system were adipose fin clipped indicating that they were returns from the Russian River Coho Salmon Broodstock Program. While only 6 adult coho were detected during video monitoring, it is important to note that many of the coho spawning streams included in the Coho Broodstock Program are located downstream of the Mirabel fish counting facility. In addition, the coho run extends beyond the period of time that the cameras were operated.

Steelhead

Steelhead counts ranged from 56 to 1,806 since 2000, including 154 in 2009 (Table 8.3.10). Since the majority of the steelhead run in the Russian River occurs after Mirabel Dam is deflated, these counts are not representative of run size and cannot be used to compare steelhead runs between years. Steelhead were categorized by being of wild, hatchery, or unknown origin. In the past 5 years adult steelhead have only been observed in large numbers during 2007 when the video monitoring system was operated during fall and spring. In 2007, 1,806 adult steelhead (284 wild, 686 hatchery, 790 unknown origin) were counted during spring and fall video monitoring, combined (Figure 8.3.8). In all years few adult steelhead were observed prior to the last week of November (Table 8.3.5). In the spring of 2007 the cameras operated during January, February, April, May and June (8, 5, 22, 31, and 27 days respectively). Adult steelhead apparently begin migrating through the Russian River in late November, with peak months likely being December through March (based on hatchery returns to Warm Springs Fish Hatchery).

Table 8.3.10. Fall steelhead counts at the Mirabel Dam fish counting station in the fall of 2000-2009.

Date	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
8/1	0	0	0	0	0	0	0	0		
8/8	0	0	0	0	0	0	0	0		
8/15	0	0	0	0	0	0	0	0	0	0
8/22	0	0	0	0	0	0	0	0	0	0
8/29	0	0	0	0	0	0	0	0	0	0
9/5	0	0	0	0	0	0	0	0	0	1
9/12	0	0	0	0	0	1	0	0	0	0
9/19	0	0	0	0	0	0	0	0	0	0
9/26	0	0	0	0	0	0	0	0	0	0
10/3	1	0	2	0	0	1	0	0	2	0
10/10	0	0	0	1	0	2	0	1	1	9
10/17	0	0	3	0	1	3	0	0	0	19
10/24	2	0	1	2	6	3	1	0	1	1
10/31	2	0	3	0	0	2	0	0	9	2
11/7	1	0	18	4	3	12	6	0	5	8
11/14	7		10	18	14	9	25	4	15	2
11/21	11		1	17	34	21		15	4	12
11/28	56		9	36	97	14		194	35	18
12/5	43		55		52			46	18	33
12/12	178								112	51
12/19	87								55	
12/26	24									
1/2	45									
1/9	56									
TOTAL	**513**	**0**	**102**	**78**	**207**	**68**	**32**	**260**	**256**	**156**

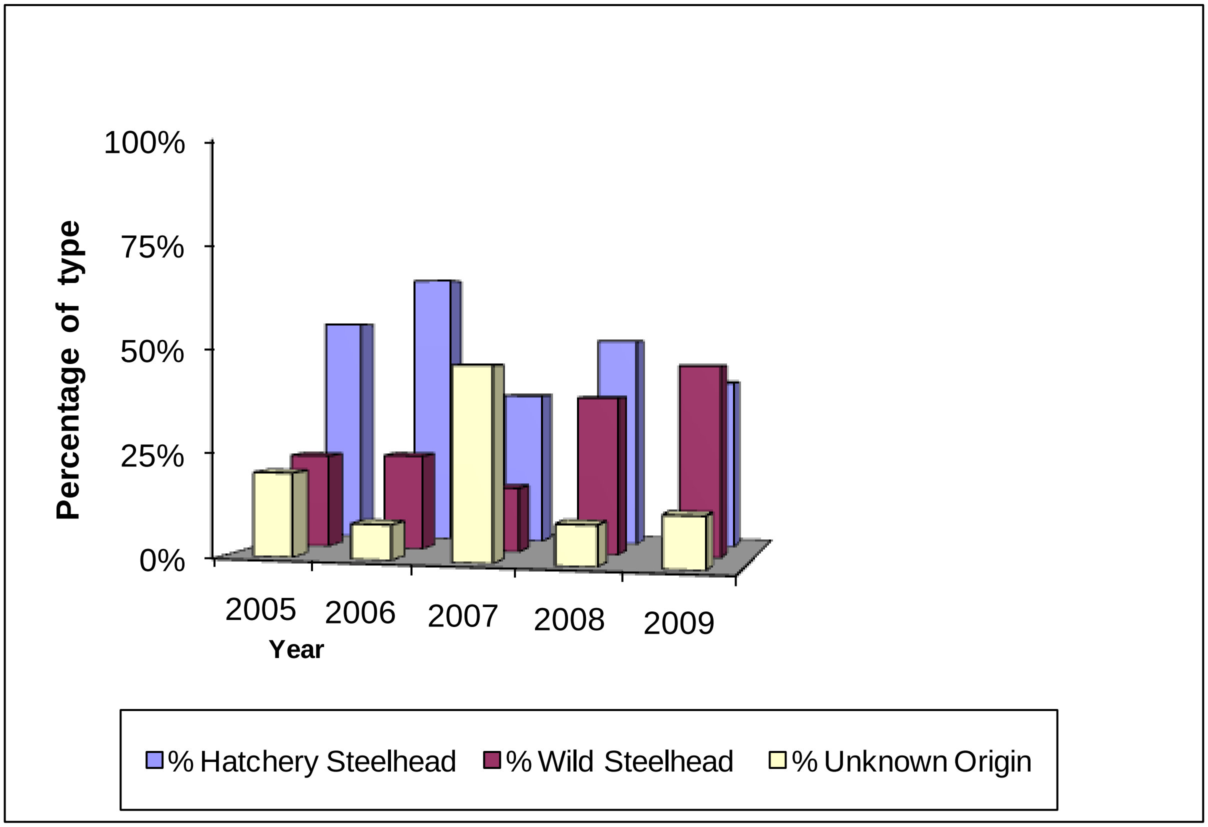


Figure 8.3.8. The proportion of hatchery, wild, unknown origin, and estimated from unidentified salmonid) per year.

Conclusions and Recommendations

In most years over the past decade the video counting system was in operation throughout the majority of the Chinook salmon run. However, direct comparison of population size between years is hindered by a number of factors. Because the fish ladders only operate when the dam is inflated, sampling periods for the video system varied each year. From 2000 to 2009, the date that the dam was deflated has ranged from November 13 to January 10. Periods of high turbidity also limited fish observations for short periods during all years. Although the number of Chinook salmon counted each year underestimates true escapement, the numbers represent the relative strength of the run, and therefore are useful for tracking trends.
Species observed in the last 10 years include, but are not limited to Chinook and coho salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, common carp, and channel catfish. Most of the non-anadromous species were noted as "milling around" in the exit boxes, as opposed to migrating upstream or downstream through the fish ladders.

Based on the results of video monitoring from 2000 through 2009, Chinook salmon and steelhead appear to successfully find and ascend the fish ladders. Relatively high numbers of adult fish of both species have been documented negotiating the ladders and comparatively few fish are observed at the base of the dam.

Based on the sampling effort to date, the adult Chinook salmon migration season begins in September, peaks during late-October and mid-November, and slowly diminishes through December. Chinook salmon tend to move in large schools up the Russian River. In November of 2008, approximately 45 percent of the total run was counted during one week. Peaks in the migration period are typically associated with rain events and increases in river flow. However, increases in river flow from rain events do not account for all peak movements of fish counted at Mirabel Dam. A sand bar that formed in early September of 2009 blocked Chinook from entering the estuary until October 6, 2009. As a result, the Chinook migration started later in 2009 than any other year on record.

9: Chinook Spawning Ground Surveys

Although not an explicit requirement of the Biological Opinion, the Water Agency has and will continue to perform spawning ground surveys for Chinook salmon in the mainstem Russian River and Dry Creek. This effort compliments the required video monitoring of adult fish and has been stipulated in temporary D1610 flow change orders issued by the State Water Resources Control Board to satisfy the Biological Opinion (see Pursue Changes to D1610 flow chapter of this report). The Water Agency began conducting Chinook salmon spawning surveys in fall 2002 to address concerns that reduced water supply releases from Coyote Valley Dam (Lake Mendocino) may impact migrating and spawning Chinook salmon (Cook 2003). Spawner surveys in Dry Creek began in 2003.

The primary objectives of the spawning ground surveys are to (1) characterize the distribution and relative abundance of Chinook salmon spawning sites, and (2) compare 2008 and 2009 results with findings from previous study years. A secondary objective was to characterize spawning gravels along the Russian River in Ukiah Valley and Alexander Valley. Background information on Chinook salmon life cycle and natural history in the Russian River presented in previous annual reports (Cook 2003 and 2004) has been incorporated into this report.

Methods

Chinook salmon redd (spawning bed) surveys in the Russian River were conducted from fall 2002 to 2009 in the upper Russian River basin and Dry Creek. The study area included approximately 114 km of the Russian River mainstem from Riverfront Park (40 rkm) located south of Healdsburg upstream to the East and West Forks of the Russian River (154 rkm) near Ukiah. In 2003, the study area was expanded to include 22 km of Dry Creek below Warm Springs Dam at Lake Sonoma to the Russian River confluence. Surveys in 2005 along the mainstem and Dry Creek were incomplete due to excessive turbidity and unsafe boating conditions (Cook 2006). Only a portion of Dry Creek was surveyed in 2008 due to limited property access. The Russian River and Dry Creek study area was partitioned into 6 reaches based on gradient and surrounding topography, including (Figure 9.1):

1) Lower Healdsburg reach (Riverfront Park to Dry Creek confluence),
2) Upper Healdsburg reach (Dry Creek confluence to Alexander Valley Road bridge),
3) Alexander Valley reach (Alexander Valley Road bridge to Big Sulphur Creek confluence),
4) Canyon reach (Big Sulphur Creek confluence to Highway 101 bridge near Hopland),
5) Ukiah reach (Highway 101 bridge near Hopland to East and West Forks confluence), and
6) Dry Creek reach (Russian River confluence to Warm Springs Dam).

Surveys were conducted to determine the distribution and relative abundance of Chinook salmon redds and the habitats utilized for spawning. The study area was surveyed once in November or December in each survey year. A crew of 2 or 3 biologists in kayaks would visually search for redds along the streambed. The locations of redds were recorded using a global positioning system (GPS). Habitat characteristics of spawning sites (i.e., substrate size, water depth, and velocity, etc) were qualitatively described.

The number of redds counted during surveys is unlikely to be the actual number of redds constructed during the annual spawning period. As previously described, redd surveys were conducted after video monitoring indicated a peak in migration activity; however, it is likely that additional redds were constructed after the single-pass survey of the study area. Additionally, identification of individual redds was difficult at high density spawning grounds because some redds were covered or obscured by overlapping redds. Chinook salmon may also spawn in low numbers in the larger tributaries located outside of the study area.

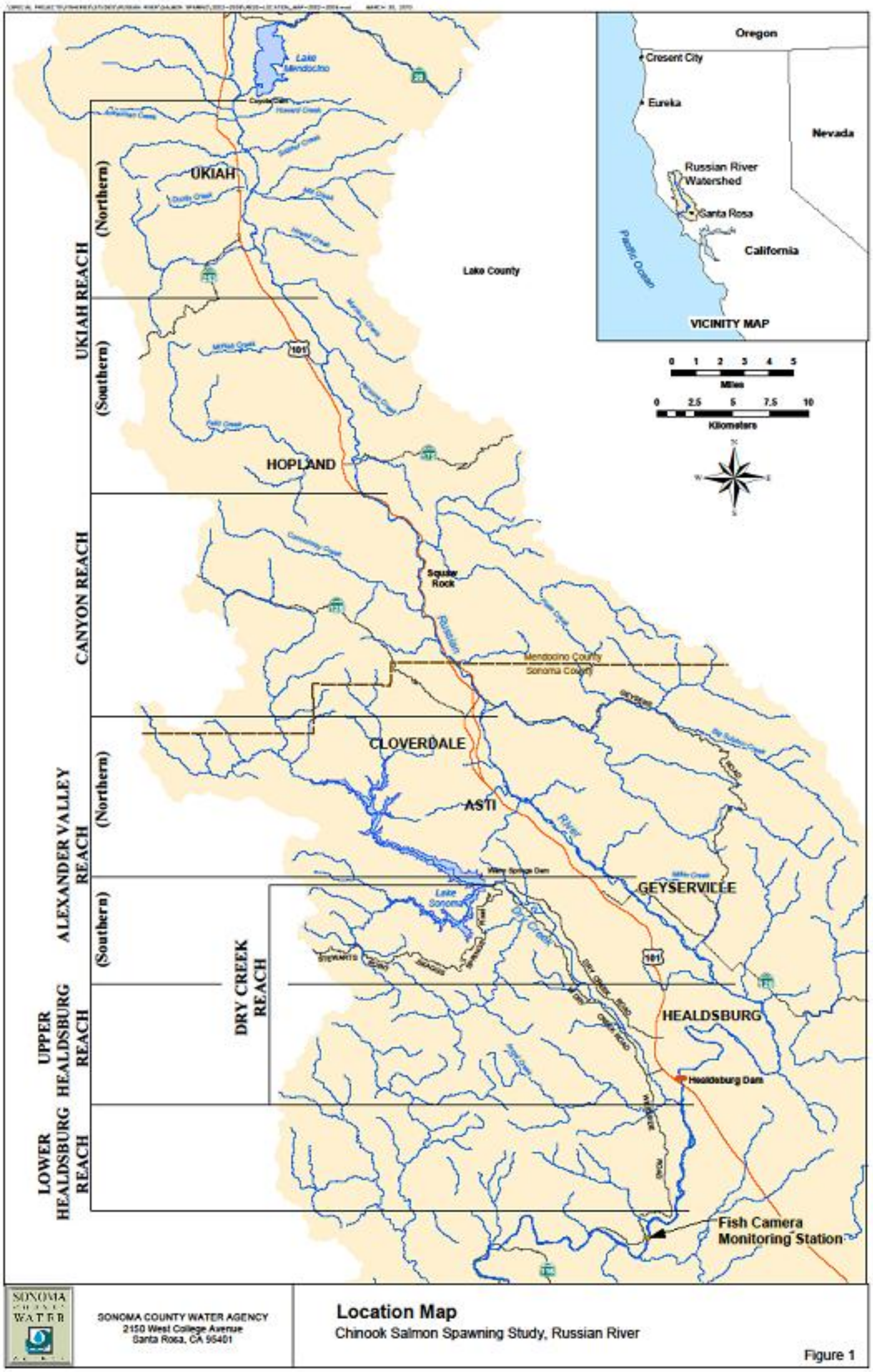


Figure 9.1. Chinook salmon spawning survey reaches.

Results

The locations of Chinook salmon redds in the Russian River and Dry Creek were similar during the 7 years of study (Appendix G-1). There were few redds observed in the Lower Healdsburg reach and most were found near the confluence with Dry Creek. Redds in the Upper Healdsburg reach were clustered in the center and upstream end of the reach. In Alexander Valley, redds were clustered in the center of the reach. Redds were distributed throughout both the Canyon and Ukiah reaches. In the Dry Creek densities were highest in the upper part of the reach. Redds throughout the study area were found almost exclusively at the downstream end of pools or the upstream end of riffles; coarse gravel to small cobble dominated and water depths typically exceeded 20 cm. These substrate and water depth conditions are uncommon in the Lower and Upper Healdsburg reaches where the stream gradient is low, resulting in few riffles. This is likely a major factor limiting the distribution of redds in these reaches. The number of Chinook salmon redd observations in the upper Russian River mainstem declined during the study period from 2002 to 2008 with a slight increase in 2009 (Figure 9.2; Table 9.1). Redd numbers in the mainstem Russian River were highest during 2002 (1,036 redds) and lowest in 2008 (178 redds).

Based on reach length, the relative contribution of redds in Dry Creek to the overall number of redds in the basin was proportionately greater than in the Russian River mainstem (Table 9.1). Dry Creek reach consisted of 16% (21.7 km) of the study area compared to 84% (113.9 km) of the upper Russian River mainstem, yet Dry Creek contained from 22% (2003) to 45% (2009) of the redds observed annually.

The abundance of redds generally increased with distance upstream in the Russian River mainstem (Figure 9.3). Most of the Chinook salmon spawning occurred in the upper 3 reaches of the Russian River mainstem and in Dry Creek (Table 9.1). The Lower and Upper Healdsburg reaches had relatively low frequencies of redds (0.0 to 3.7 redds/km) compared to the Alexander Valley, Canyon, and Ukiah reaches located upstream (0.6 to 15.5 redds/km; Table 9.2). The Ukiah reach, located at the upstream end of the Russian River, typically had the highest frequency of redds annually in the mainstem, reaching a high of 15.5 redds/km in 2002. Dry Creek consistently had the highest redd frequency of all study reaches (15.8 redds/km) in 2004. In the Ukiah and Dry Creek reaches, the abundance of redds generally increased with proximity to the upstream ends of each reach (Figures 9.4 and 9.5). Dry Creek is accessible to Chinook salmon from the Russian River confluence to Warm Springs Dam at Lake Sonoma and the mainstem Russian River is accessible to Chinook salmon as far upstream as Coyote Dam. The pattern of abundance of redds in both these reaches was similar each year. The upper half of the Dry Creek reach contained greater than 80% of the redds annually. A similar pattern was observed in the Ukiah reach where, except for 2008, greater than 62% of the redds were contained in the upper half of the reach. The highest frequency of redds at Dry Creek was always at the upper terminal end, with as high as 55.0 redds/km in 2004.

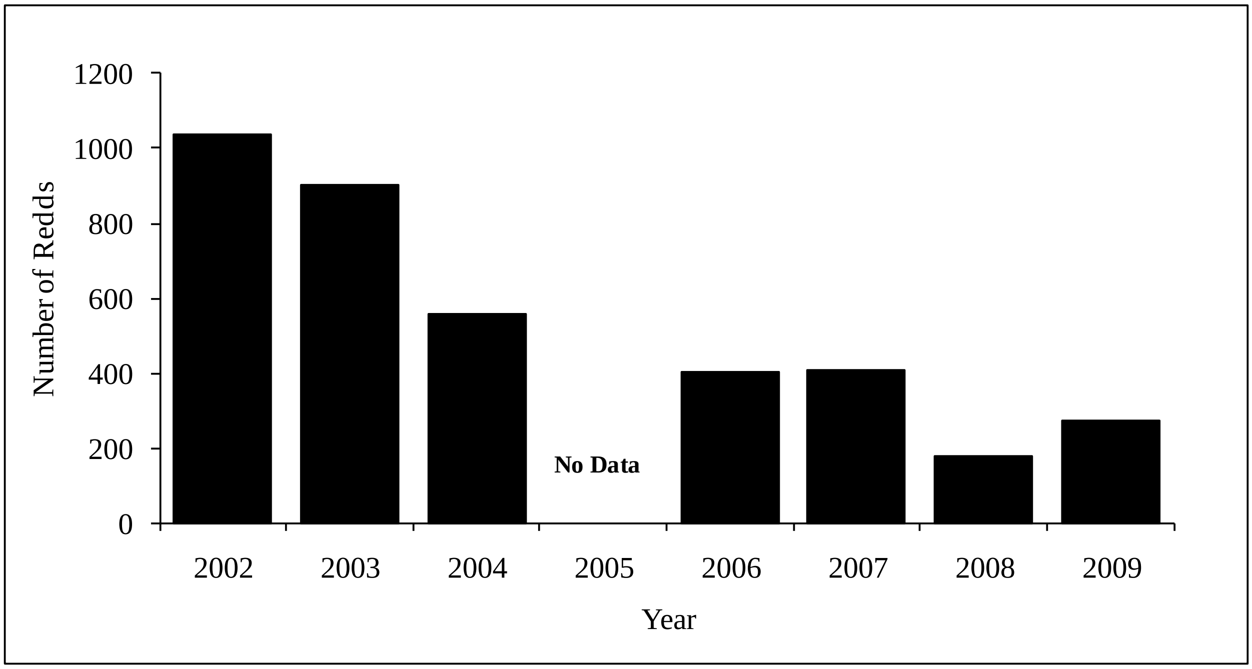


Figure 9.2. Chinook salmon redds in the upper Russian River mainstem, 2002-2009. Redd counts are from single-pass surveys.

Table 9.1. Chinook salmon redd abundances by reach, upper Russian River and Dry Creek, 2002-2009. *Survey either not completed or incomplete. Dry Creek value for 2008 is an estimate.

Reach	Reach (rkm)	2002	2003	2004	2005	2006	2007	2008	2009
				Redd Observations					
Redd Count									
Ukiah (Forks - Hwy101)	33.1	511	458	284	*	248	118	20	38
Canyon (Hwy101-Sulphur Cr)	20.8	277	190	169	*	68	88	36	38
Alexander (Sulphur Cr – Alexander Valley Rd)	26.2	163	213	90	*	62	131	65	129
Upper Healdsburg (Alexander Valley Rd - Dry Cr)	25.6	79	40	8	*	23	67	48	38
Lower Healdsburg (Dry Cr - Wohler Bridge)	8.2	6	0	7	*	1	2	9	30
Russian River Subtotal	**113.9**	**1036**	**901**	**558**		**402**	**406**	**178**	**273**
Dry Creek (Dam-River)	21.7	*	256	342	*	201	231	65	223
Total	**135.6**		1157	900		603	637	243	496
Relative Contribution of Redds									
Russian River (%)	84.0%		77.9%	62.0%		66.7%	63.7%	73.3%	55.0%
Dry Creek (%)	16.0%		22.1%	38.0%		33.3%	36.3%	26.7%	45.0%
Total	100%		100%	100%		100%	100%	100%	100%

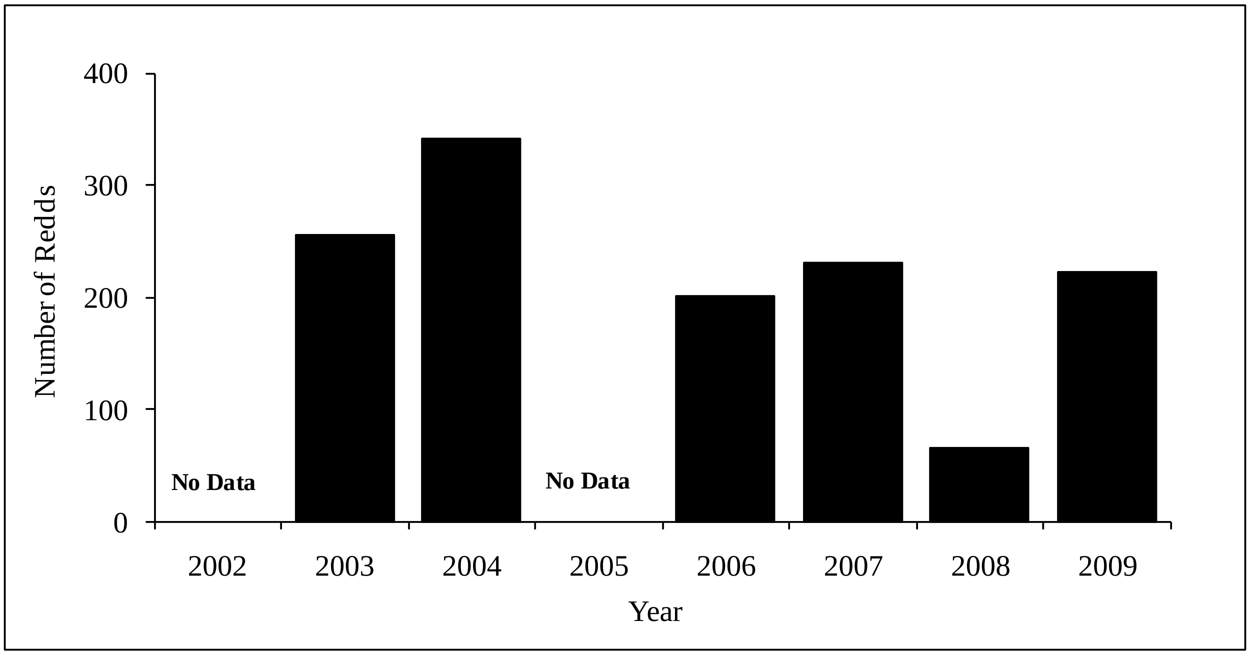


Figure 9.3. Chinook salmon redds in Dry Creek, 2002-2009. Redd counts are from single pass surveys. The 2008 value is a proportional estimate based on a partial survey of the reach.

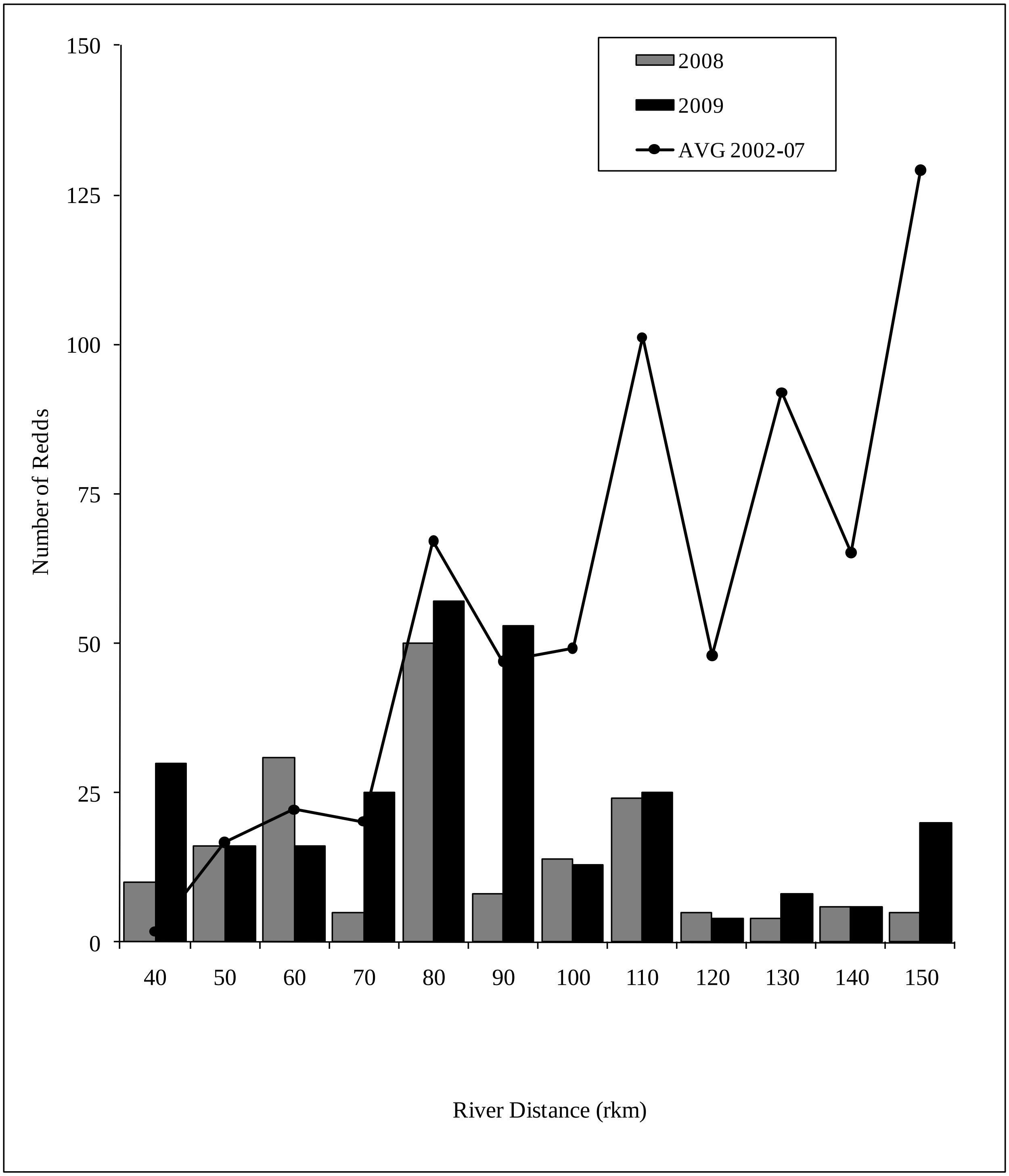


Figure 9.4: Chinook salmon redd observations in the upper Russian River, 2002 - 2009.

Table 9.2. Chinook salmon redd frequencies by reach, upper Russian River and Dry Creek, 2002- 2007. *Survey either not completed or incomplete.

		Redd/rkm							
Reach	**Reach (rkm)**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Ukiah (Forks - Hwy101)	33.1	15.5	13.8	8.6	*	7.5	3.6	0.6	1.1
Canyon (Hwy 101 – Sulphur Cr)	20.8	13.3	9.1	8.1	*	3.3	4.2	1.7	1.8
Alexander (Sulphur Cr - AV Rd)	26.2	6.2	8.1	3.4	*	2.4	5.0	2.5	4.9
Upper Healdsburg (AV Rd - Dry Cr)	25.6	3.1	1.6	0.3	*	0.9	2.6	1.9	1.5
Lower Healdsburg (Dry Cr - Wohler Bridge)	8.2	0.7	0.0	0.9	*	0.1	0.2	1.1	3.7
Russian River (all mainstem reaches)	**113.9**	**9.1**	**7.9**	**4.9**		**3.5**	**3.6**	**1.6**	**2.4**
Dry Creek (WS Dam - Russian River)	21.7	*	11.8	15.8	*	9.3	10.6	3.0	10.3

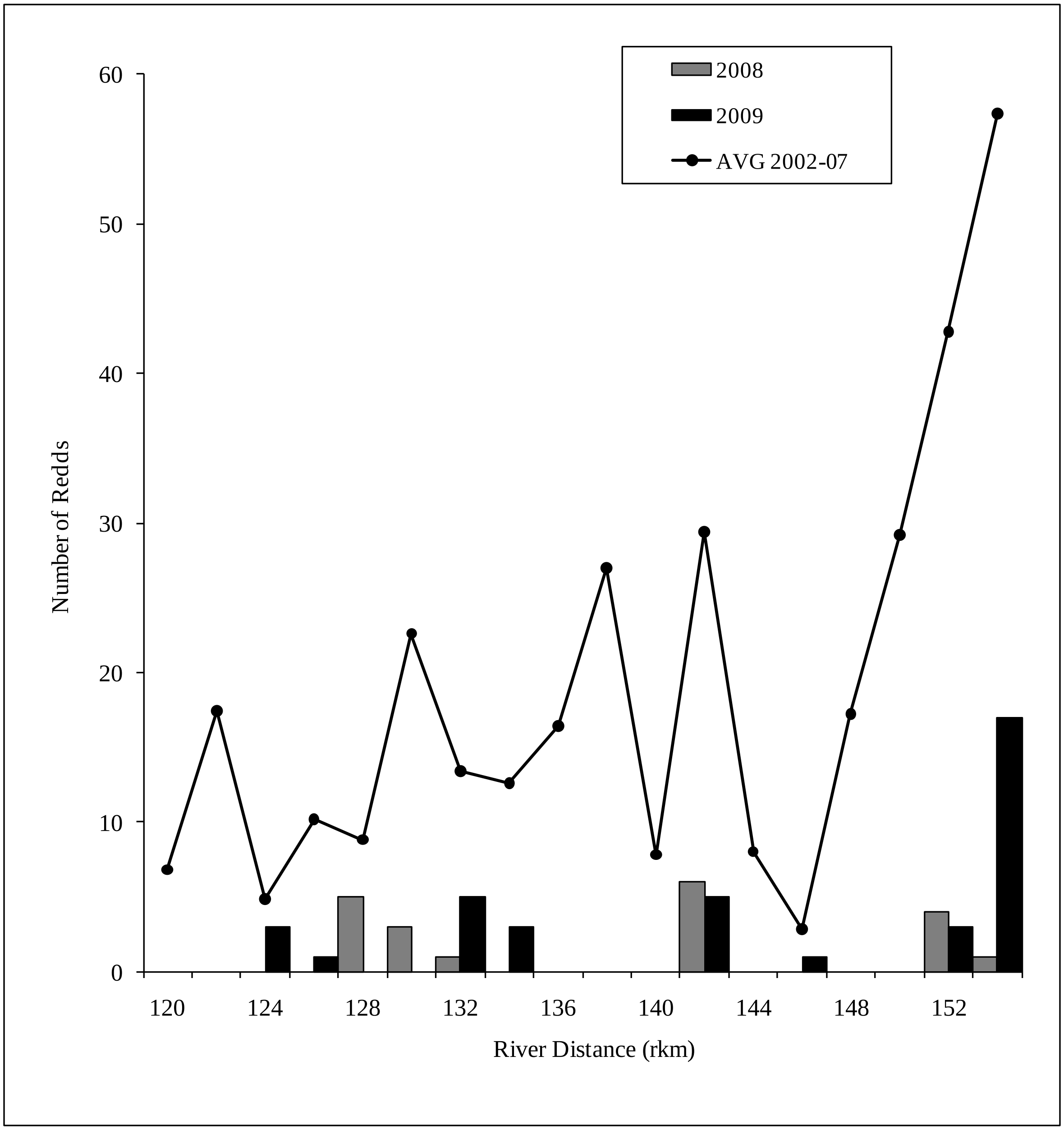


Figure 9.4: Chinook salmon redds in the Ukiah reach, Russian River. Ukiah reach river distances are from rkm 120 located downstream of Highway 101 bridge (Hopland) to rkm 154 near the East and West Forks.

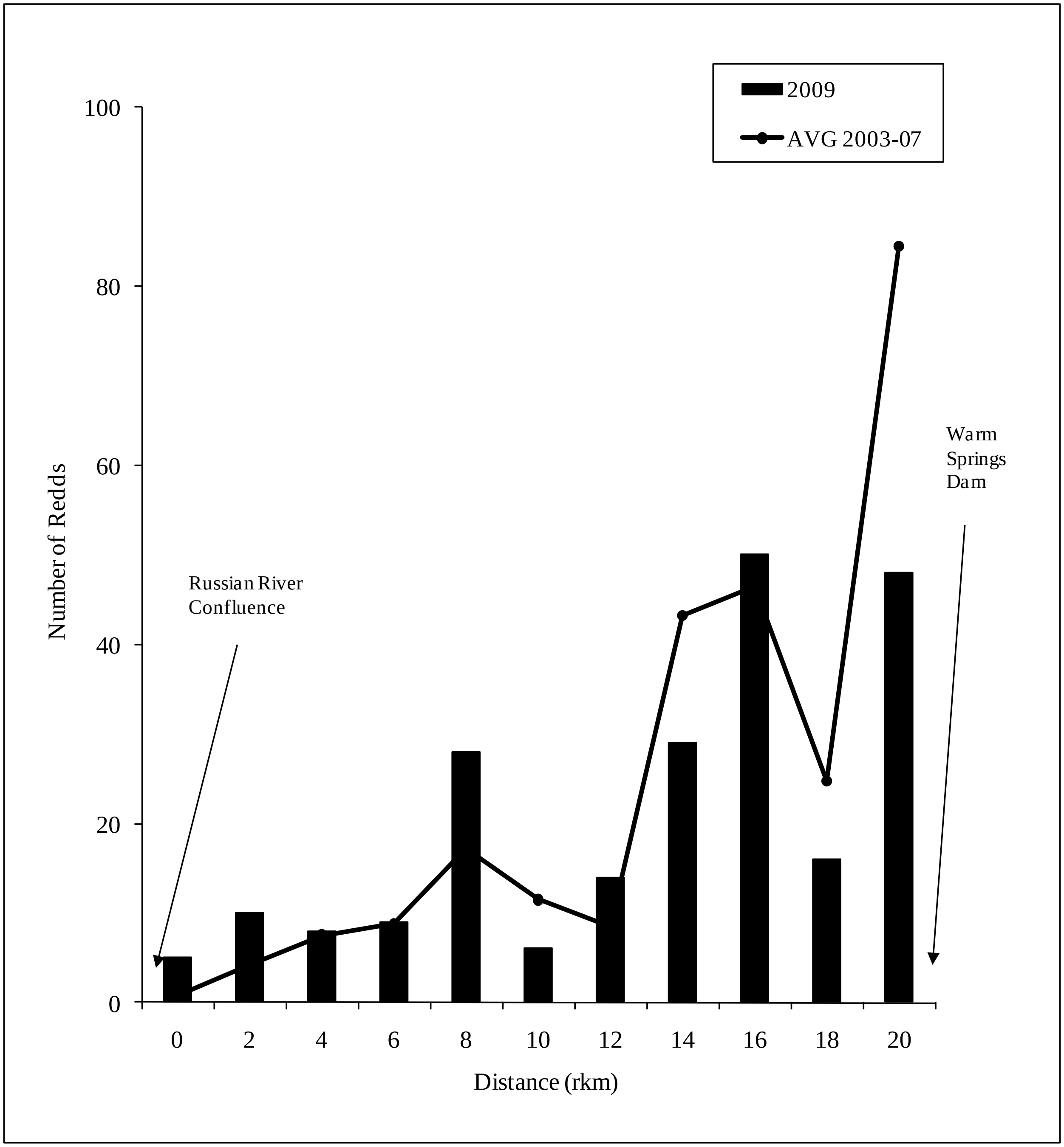


Figure 9.5: Chinook salmon redds in Dry Creek. River distances extend from the Dry Creek confluence with the Russian River (rkm 0) to Warm Springs Dam at Lake Sonoma (rkm 22).

Conclusions and Recommendations

In 2009, 1,801 Chinook salmon were observed passing through the fish ladders at Mirabel Dam and 496 redds were counted in the upper Russian River and Dry Creek. The higher counts of adult Chinook salmon observed during video monitoring compared to redd counts suggests that more redds were constructed than we observed. This discrepancy is probably due to spawning after our single-pass surveys were completed, superimposition (overlapping) of constructed redds, and spawning in tributaries that were outside of the study area.

The primary Chinook salmon spawning areas in the Russian River basin are located from Alexander Valley upstream to Ukiah Valley and in Dry Creek. Redds were least abundant in the Lower Healdsburg and Upper Healdsburg reaches. Chinook salmon redds were typically concentrated in the Ukiah Valley and Dry Creek reaches closest to the dams. Releases of relatively cool, high flows of water from these dams are strong attractants for migrating Chinook salmon. Spawning in the lower Russian River (downstream of Mirabel Dam) is likely minimal based on the low river gradient and lack of riffles with suitable spawning gravel.

10: Synthesis

As has been outlined in portions of this report leading to this chapter, the Sonoma County Water Agency has collected a variety of fish and water quality monitoring data relevant to fulfilling the overall objectives in the Russian River Biological Opinion. The objectives specific to this synthesis chapter are to relate these data by (1) illustrating the spatial and temporal extent of monitoring activities; (2) depicting some of the general conditions prevailing in the Russian River in 2009 that fish may have faced; (3) comparing data collected at various sites so that we can begin to understand spatial variability within the system; and (4) identifying and outlining new approaches and questions relative to the RPA that have emerged as a result of ongoing monitoring efforts. The approach to accomplishing these objectives is based on relating data from various monitoring activities so that we can offer the perspective necessary to evaluate whether those activities are sufficient or are likely to be sufficient for meeting the objectives in the RPA in 2009 and beyond. The approach of combining data from various monitoring sources should also give us a sense of the range in variability within and among sites in a single year, while forming a template for comparing the range of variability among years. An understanding of the inherent variability in the habitat and populations it supports is a common and key element that will serve our goal of maximizing the benefit of our actions to anadromous salmonid populations in the Russian River Basin.

The timing of fish presence in a given portion of the watershed will dictate the extent to which fish are exposed to local habitat conditions that may be beneficial, detrimental, or neutral. For example, the rate of smolt-movement through the system, and distance between points of interest strongly influence the habitat conditions fish encounter. While distances between these points remain static, movement rates may be affected by species, timing of movement (e.g., early, middle, late), individual variability (e.g., size), environmental factors that influence speed of movement (e.g., stream velocity), as well as complex interactions among these factors. Without empirical data it will remain difficult to predict that timing. Nevertheless, it is important to keep in mind that these factors, in addition to the within- and among- year variability inherent to the system, are key to understanding the role of local habitat conditions in shaping anadromous salmonid populations in the basin. Further, it is important to understand how management changes outlined in the RPA may manifest themselves in terms of intended as well as possible unintended consequences.

Sampling Methods And Spatial Extent

We begin by illustrating the spatial (Figure 10.1a, b) and temporal extent (Figure 10.2) of our sampling in 2009. Between April 1 and December 12, we collected data from 23 sites in the Russian River Basin. We also conducted spawner surveys on 137 km of stream length in the mainstem Russian River and Dry Creek. Sites, gear types, and target life stages monitored included: downstream migrant trapping with rotary screw traps on Dry Creek and the mainstem

Russian River at Wohler-Mirabel, and operation of a fyke net near the upstream extent of the estuary in Duncans Mills; juvenile salmonid sampling using beach seining at eight fixed locations in the estuary; continuous water quality monitoring at six locations throughout the estuary; juvenile sampling using snorkeling, electrofishing, PIT tags and PIT antennas at multiple sites in Dry Creek; adult Chinook surveys using underwater video at Wohler-Mirabel and from spawner surveys in the upper mainstem and Dry Creek. Complementary data on water quality were collected by means of continuously-recording datasondes as well as grab samples. Details regarding the specifics of these monitoring activities are covered in individual chapters of this report.

Smolts

We suspect that the relatively low capture of wild steelhead smolts at downstream migrant traps in 2009 was due to a combination of factors including low trap efficiency for steelhead smolts (Chase et al. 2005, see Dry Creek chapter in this report), and the earlier timing of the steelhead smolt outmigration period as compared to our period of trap operation (Chase et al. 2005). Despite these issues and based on the low numbers of steelhead smolts captured (182 on Dry Creek, 33 at Wohler-Mirabel), the timing of outmigration at the two sites appeared to be similar (Figure 10.3).

Only 10 coho salmon smolts were captured on Dry Creek in 2009 yet three of them did not have an adipose clip which suggests they may have been naturally produced somewhere in the Dry Creek watershed. Of the 207 coho salmon smolts captured at Wohler-Mirabel, 6 did not have an adipose clip (potentially wild), 72 (35%) had PIT tags indicating they had been stocked in Mill Creek, and 13 had been previously captured at the Mill Creek downstream migrant trap operated by UCCE. The capture of coho smolts at Wohler-Mirabel in 2009 suggests that this facility may be a valuable site for assessing the coho recovery program in the Russian River system (Figure 10.3).

For Chinook salmon smolts, the timing of outmigration was markedly later in Dry Creek as compared to Wohler-Mirabel. In Dry Creek, it was not until May 7 that 50% of the season's capture had occurred while at Wohler-Mirabel 50% of the season's capture was reached on April 24 (Figure 10.3). Part of this difference could be related to the earlier start to the trapping season at Wohler-Mirabel (April 1) as compared to Dry Creek (April 7); however, we suspect that cooler water temperatures in Dry Creek may have also played an important role. We speculate that these cooler water temperatures may have also manifested themselves in differential growth rates (Figure 10.4). We hypothesize that the strikingly larger size of Chinook captured at Wohler-Mirabel as compared to Dry Creek in late-April and early-May is because the catch was comprised of a larger number of individuals that were produced in the mainstem as compared to Dry Creek. For this to be the case the timing of spawning would have to be earlier and/or water temperatures would have to be warmer in mainstem incubation/early-rearing locations. Although we do have evidence to support warmer water temperatures in the mainstem during certain portions of the year, we do not have evidence to support a difference in the timing of spawning. Nevertheless, we suggest that, to the extent possible, maintaining a mixture of environmental conditions that mimics the inherent natural variability found in the system is an important objective to include as changes to flow and estuary management are implemented.

Juveniles

Juvenile (presmolt) salmonid monitoring related to the Biological Opinion is focused on validating the effectiveness of eventual habitat enhancements in the mainstem of Dry Creek (see the Dry Creek chapter in this report) and use of the Russian River estuary by juvenile steelhead for rearing (see the Estuary chapter in this report).

To date, Water Agency monitoring efforts in mainstem Dry Creek have included (1) operation of a downstream migrant trap at Westside Road (river km 3.3); and (2) determination of appropriate population metrics and suitable methods for estimating those metrics given the challenges presented by the sampling conditions prevalent in Dry Creek. Despite the limited time period these efforts have been ongoing, some patterns have begun to emerge. For example, the number of juvenile steelhead captured at the same sites in fall 2009 and fall 2008 led us to conclude that densities in 2009 were lower than densities in 2008. This is supported by the relatively higher number of juvenile steelhead captured in the downstream migrant trap in 2009 (5,225) as compared to 2010 (2,041). We suspect that at least part of the reason for this difference is related to the overall low steelhead spawning escapement to the Russian in 2008-2009. The 1,241 adults that year represents the lowest number of returnees to the two Russian River hatcheries during the 17 year period of record and only 56% of the second lowest return year in 1993-94 (Figure 10.5). A second emerging pattern is the trend in body sizes of juvenile steelhead from the upper reach of Dry Creek (relatively small body size) as opposed to middle (relatively medium body size) or lower reaches (relatively large body size). This example of spatial variability along with the example of temporal variability suggested by our density estimates highlight the importance of incorporating background variability into how data generated from monitoring efforts on Dry Creek are interpreted.

Efforts to determine use of estuarine habitat in the Russian River by juvenile steelhead was based on (1) beach seining efforts at fixed sites throughout the estuary (see Estuary chapter); and (2) operation of a fyke net in conjunction with a live box near the upstream end of the estuary in Duncans Mills (river km=10.5) to physically capture fish moving downstream into the estuary. The Water Agency has been collecting data on fish distribution from beach seining since 2004. As has been summarized in other chapters of this report as well as in a power analysis conducted by Water Agency (2008), the spatial scale and limitations of available sampling gear will very likely limit the power of this type of sampling alone to reveal population-level responses to changes in estuary management. Because of this, the Biological Opinion outlined a new effort based on downstream monitoring (fyke net) during spring and summer to (1) estimate the timing, size (age), and relative abundance of juvenile steelhead movement into the estuary; and (2) provide a source of PIT-tagged fish for potential recapture at seining sites to estimate growth. Because of problems described earlier in this report, the number of steelhead parr captured at the fyke net in 2009 was low (59). We do not see a way to adequately address all of the problems encountered by operating a fyke net at this location and therefore conclude that the objective of physically capturing and handling fish is not advisable. Instead, in 2010 we worked with NMFS and DFG to develop and implement a new plan that incorporates an underwater video camera with a PIT-tag antenna thereby obviating the need to capture fish. This new effort shows promise particularly if it can be integrated with a larger effort to simultaneously address the estuary monitoring objectives outlined in the Biological Opinion.

Adults

The onset of adult Chinook salmon migration in the Russian River in 2009 occurred immediately following a 28 day closure period (9/7-10/4; Figure 10.6). Given the high water temperatures in the Lower River and estuary during this closure period, we speculate that the lack of access to the river by adult Chinook resulted in enhanced spawning success. During the closure, daily water temperatures at Hacienda averaged 19.9°C (range 15.4 to 23.1) while daily water temperature in the upper estuary at Freezeout Pool averaged 22.1°C (19.4 to 23.7) (Figure 10.6). Crossin et al. (2008) showed that water temperatures in excess of 18°C reduced the spawning success of sockeye by one-half. During the 28 days following the September closure, water temperatures at Hacienda and Freezeout Pool averaged 16.0°C and 17.0°C, respectively.

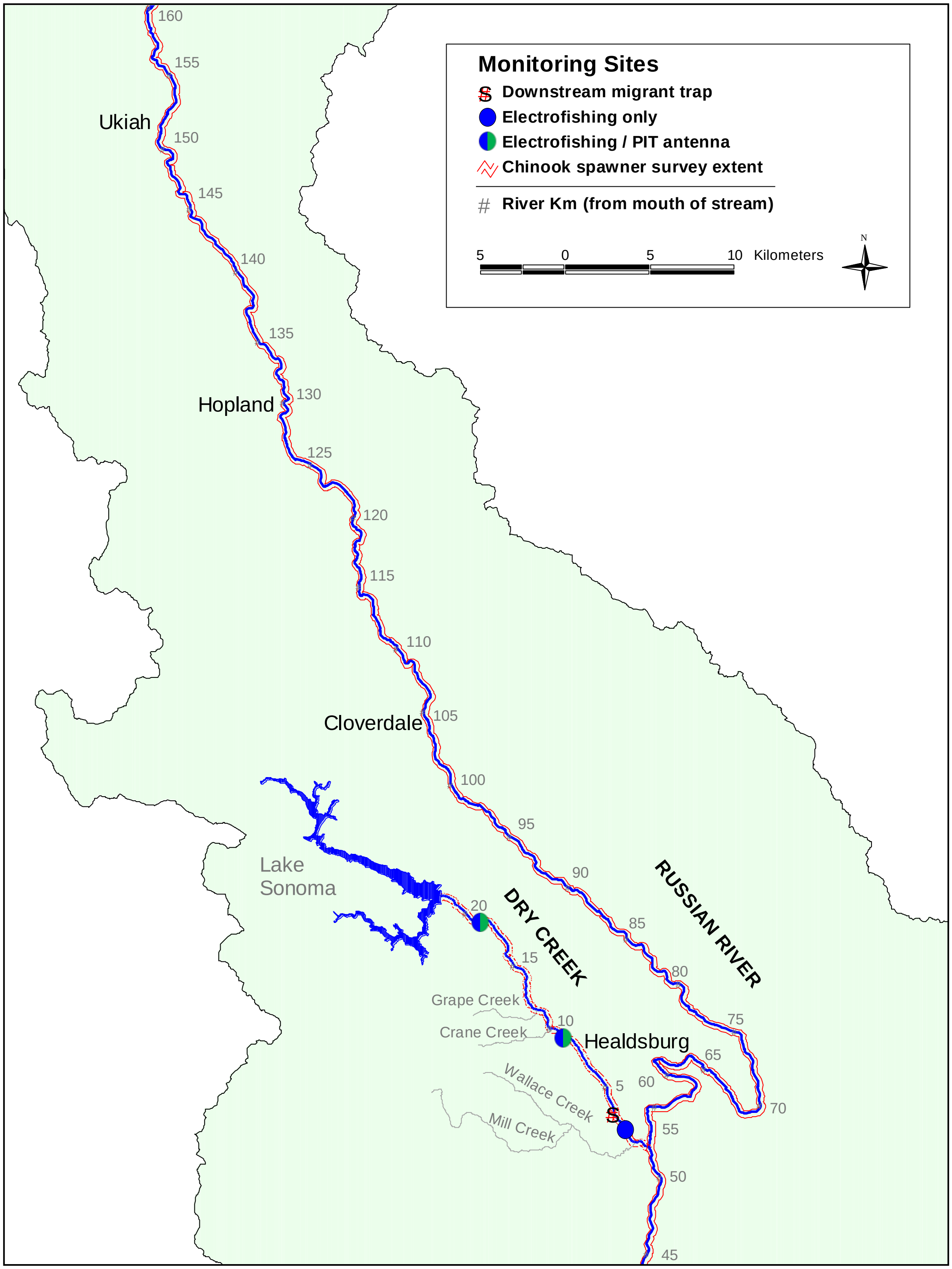


Figure 10.1a. Spatial extent of fisheries and water quality monitoring sites related to the Russian River Biological Opinion upstream of Wohler-Mirabel.

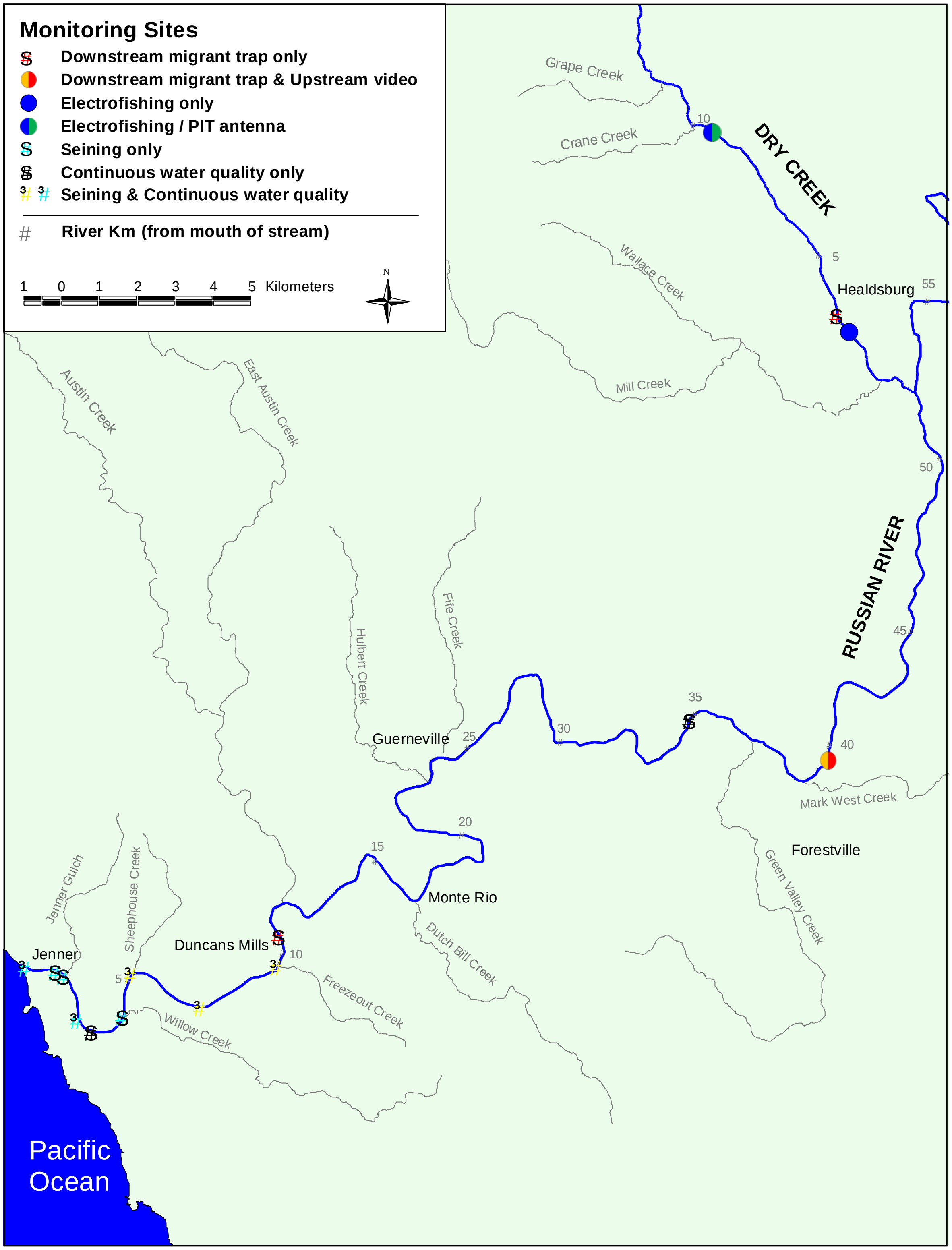


Figure 10.1b. Spatial extent of fisheries and water quality monitoring sites related to the Russian River Biological Opinion downstream of Healdsburg.

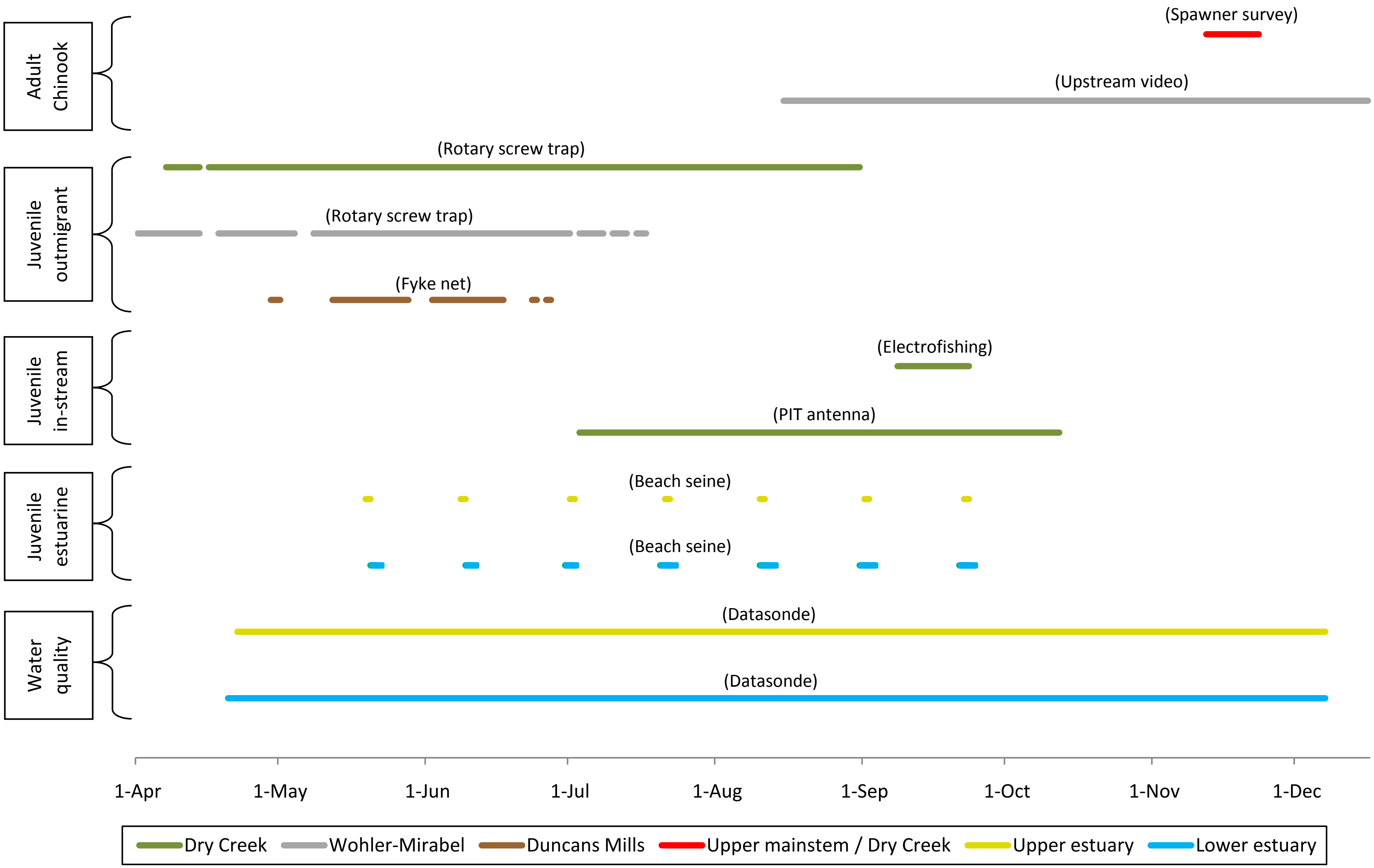
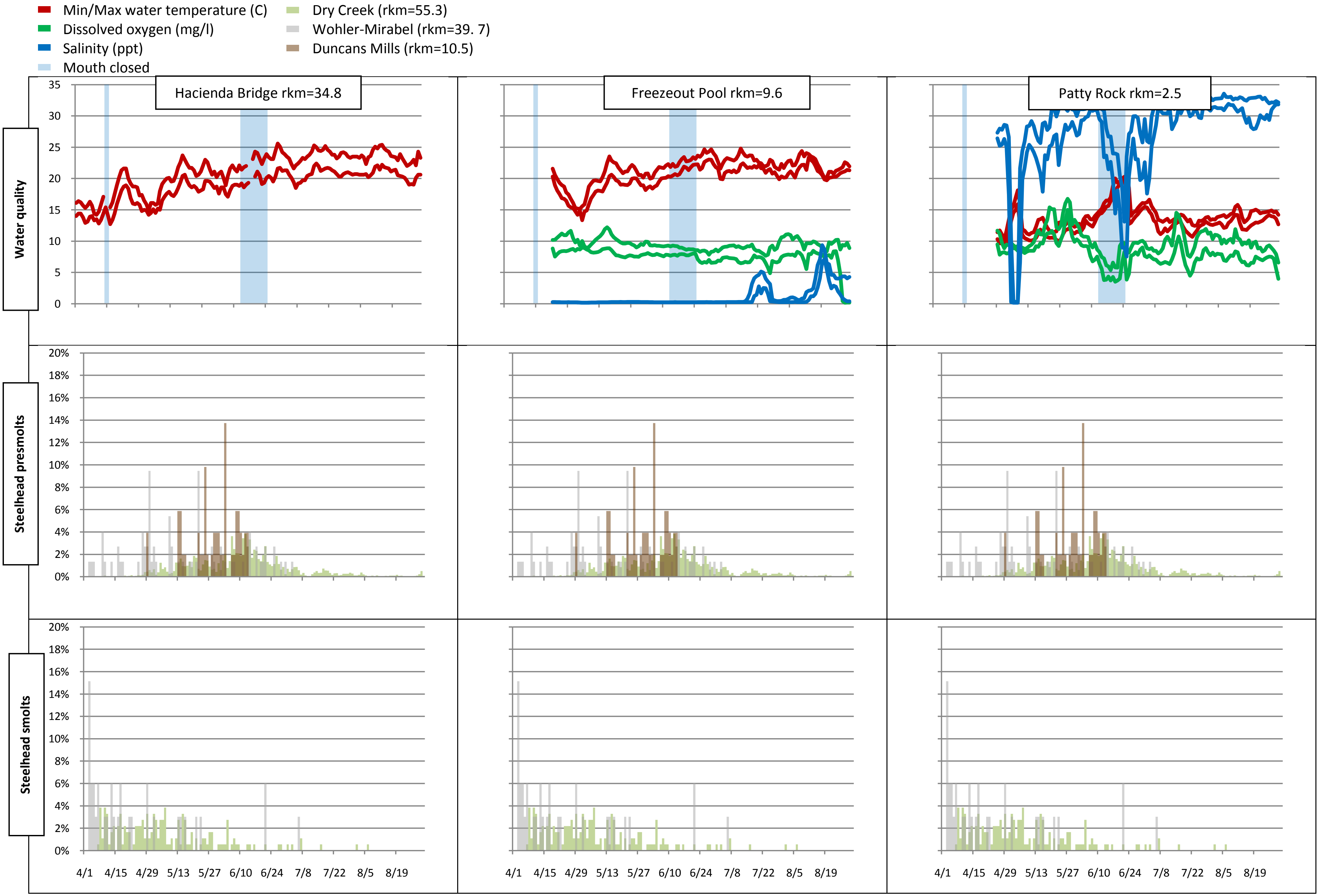


Figure 10.2. Temporal and life stage extent of sampling at fisheries and water quality monitoring sites related to the Russian River Biological Opinion.



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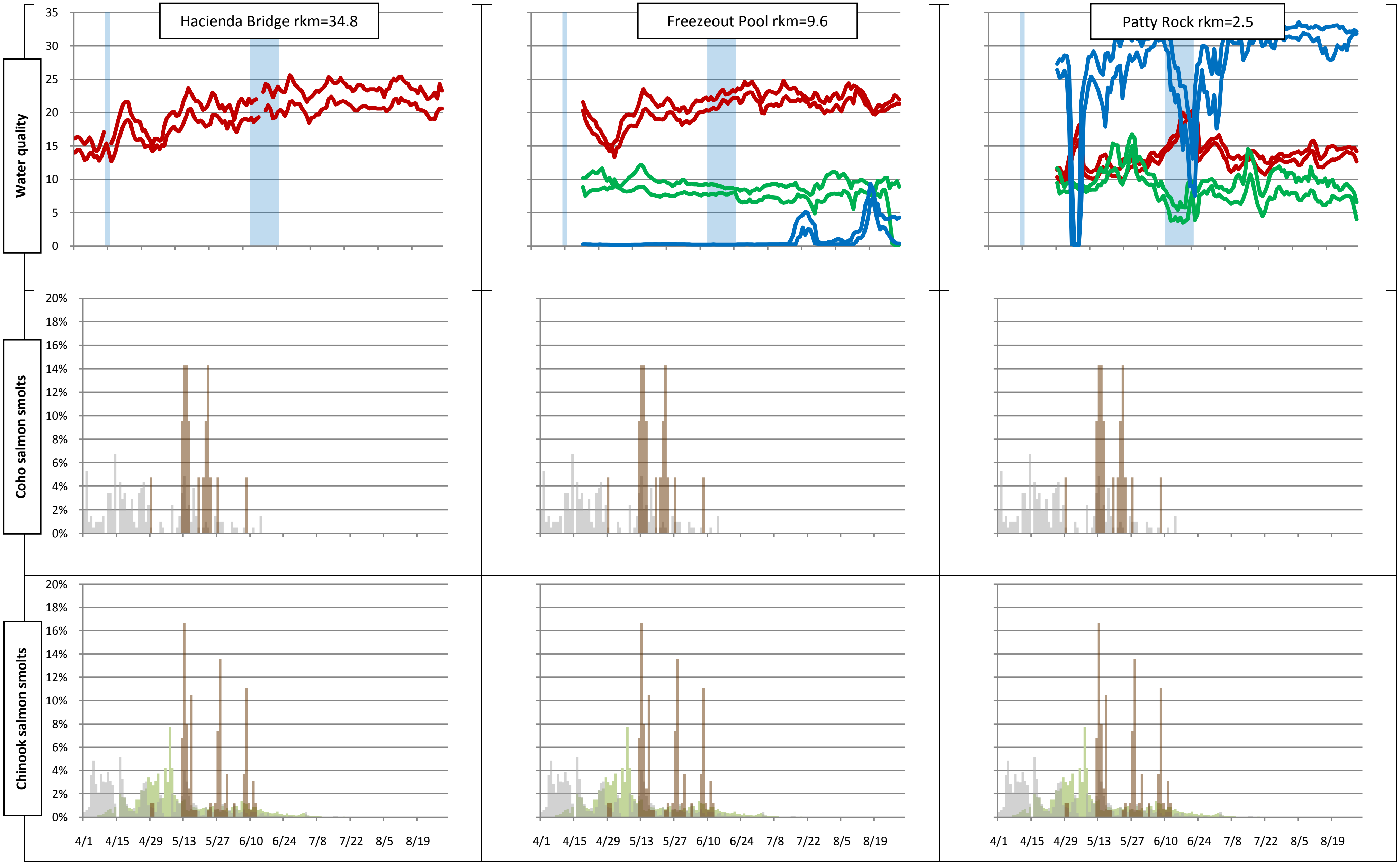

Figure 10.3. Environmental conditions in the lower mainstem (Hacienda bridge), upper estuary (Freezeout Pool), and lower estuary (Patty Rock), and proportion of total season catch by day of juvenile/smolt salmonids from downstream trapping at Dry Creek, Wohler-Mirabel, and Duncans Mills, 2009. Note that the fish capture plots for each species/life stage and site are repeated three times to facilitate comparison with environmental conditions at each water quality monitoring location.

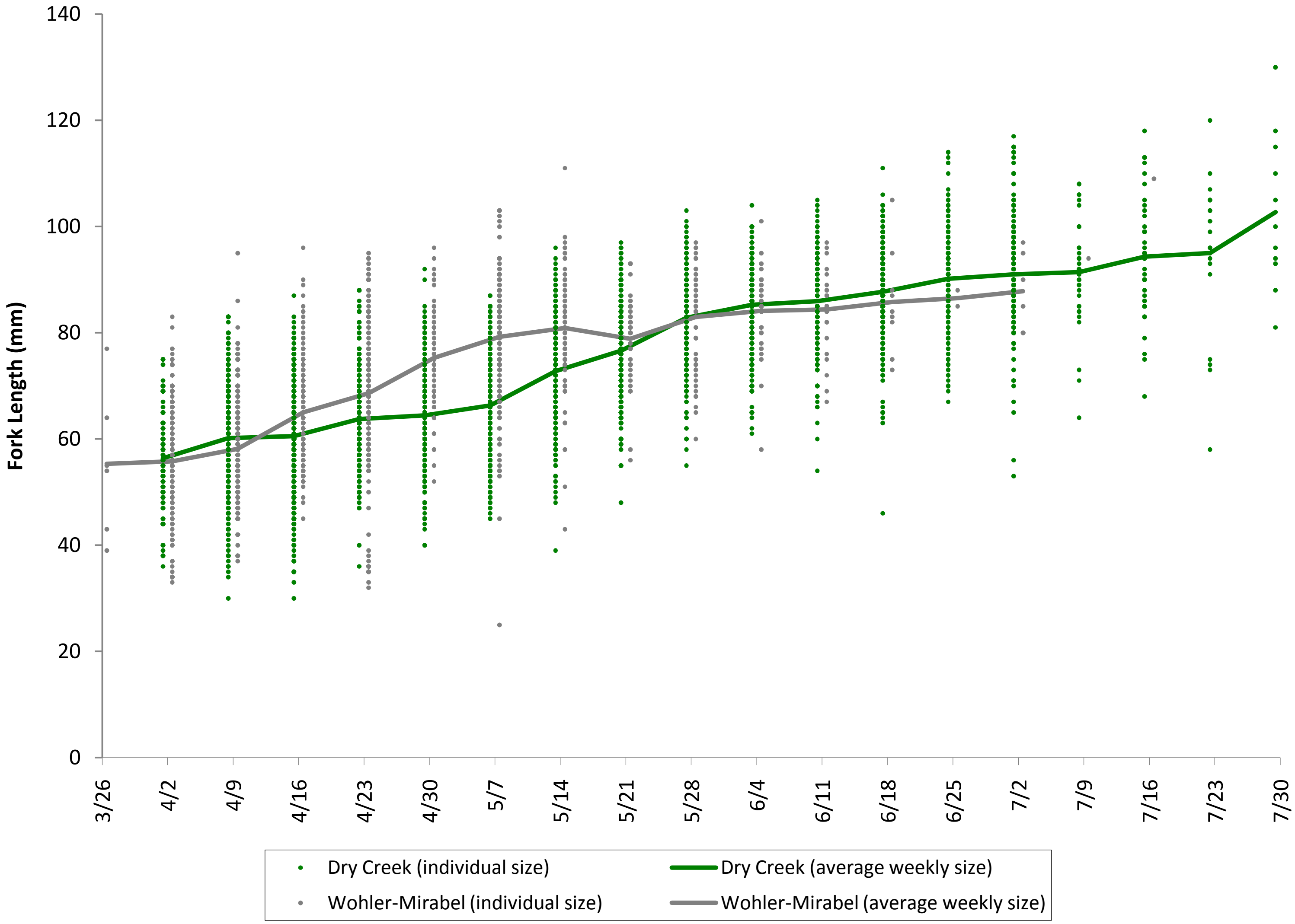

Figure 10.4. Individual and average weekly Chinook salmon smolt sizes at Dry Creek and Wohler-Mirabel, 2009.

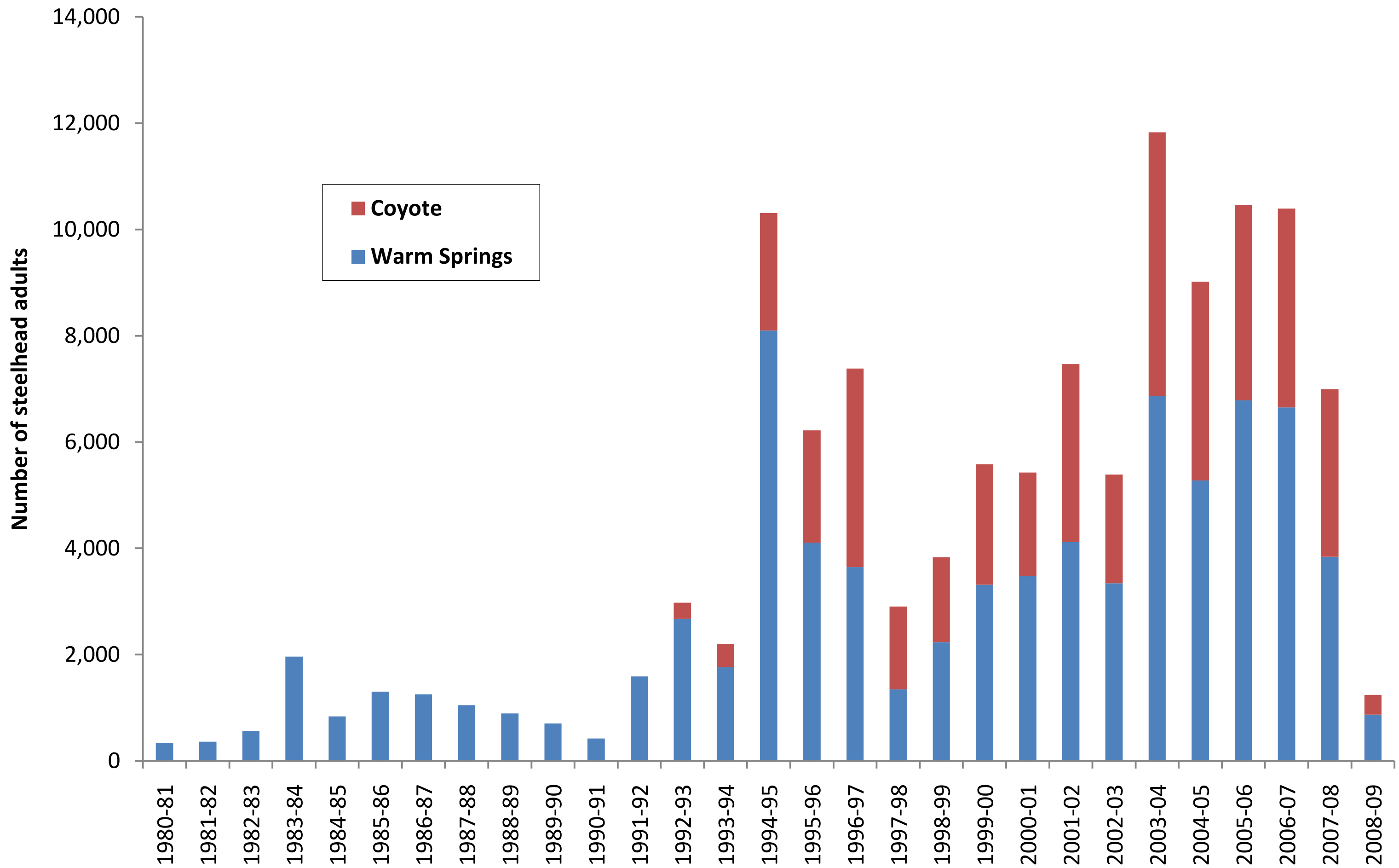

Figure 10.5. Number of adult steelhead returning to Russian River hatcheries by return year (CDFG unpublished data).

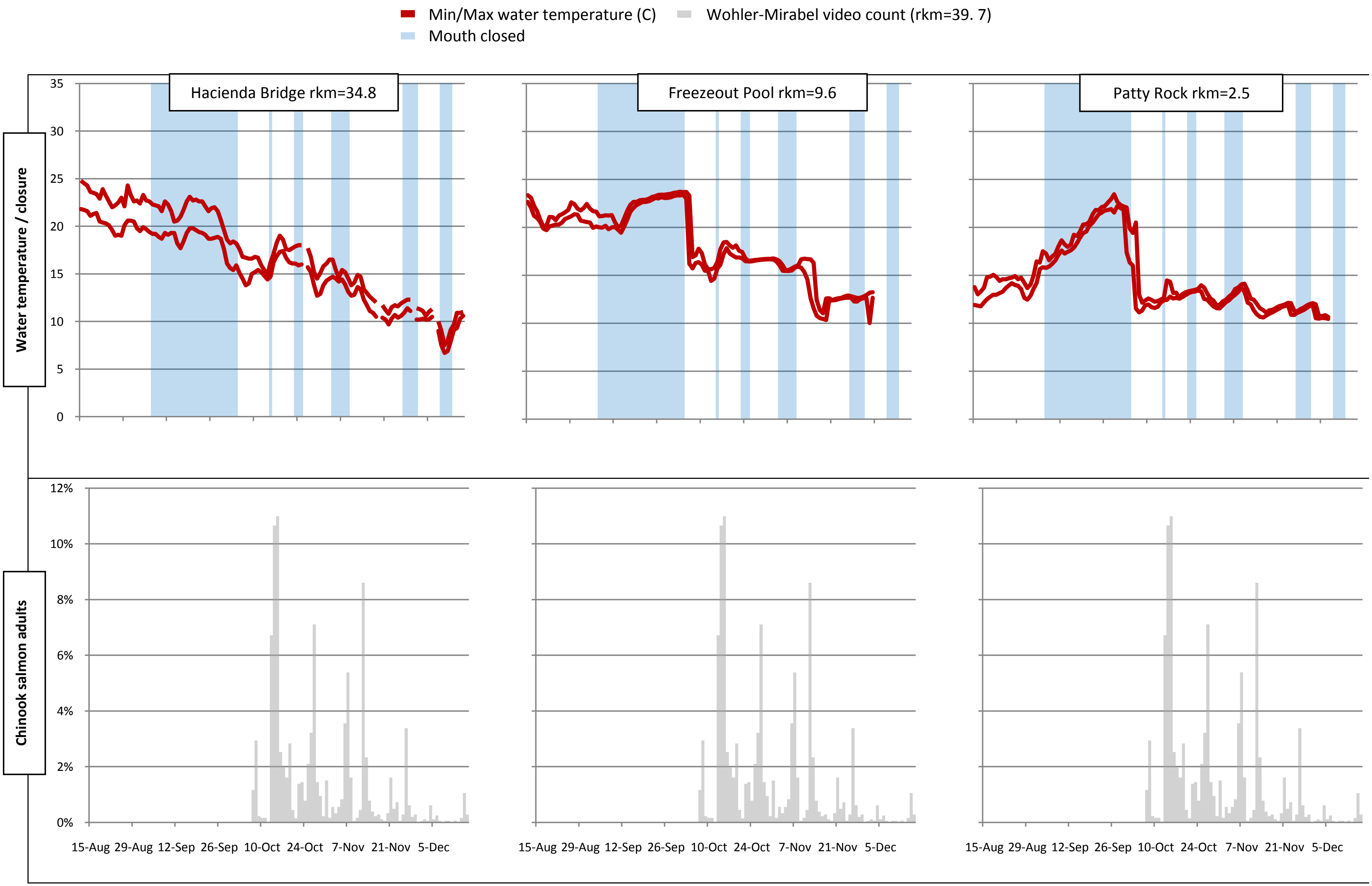

Figure 10.6. Water temperature in the lower mainstem (Hacienda bridge), upper estuary (Freezeout Pool), and lower estuary (Patty Rock); mouth closure condition; and proportion of total season detections by day of Chinook salmon adults from video monitoring at Wohler-Mirabel, 2009. Note that the Chinook salmon detection plots are repeated three times to facilitate comparison with water temperature at each water quality monitoring location.

References

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11: Appendices

All Appendices are included in the accompanying electronic media.